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THE INSTALLATION OF ELECTRIC TRACTION ON THE LONG ISLAND R. R.

For several years, work has been in progress on the Long Island R. R. for the introduction of electric traction to replace the steam locomotive on the lines of that system in Brooklyn and vicinity. The installation is now practically completed, and constitutes the most extensive work thus far undertaken anywhere in the substitution of the electric motor for the steam locomotive on lines other than those overhead or underground in city streets such as the elevated railways of New York and Chicago, or the underground railways of London.

We have been furnished through official sources with a statement of the work thus far done on the equipment of the Long Island R. R. for electric traction, together with map and photographs, all of which we present as follows:

The Western Division of the Long Island Railroad consists of numerous lines within the limits of the City of New York, and while the main terminus of the road is in Long Island City, opposite 34th St., in the Borough of Manhattan, the road has another very important terminus at the intersection of Atlantic and Flatbush avenues in the Borough of Brooklyn. The line to the latter terminus is four-tracked from Jamaica to East New York, and thence double-tracked through Atlantic Ave. to Flatbush Ave. It originally traversed open farming country, but the enormous growth of the outlying districts of the Borough of Brooklyn has resulted in building up almost solidly the section traversed by the railway line from Flatbush Ave. out to East New York, and even beyond as far as Atkins Ave., a distance of 5¼ miles.

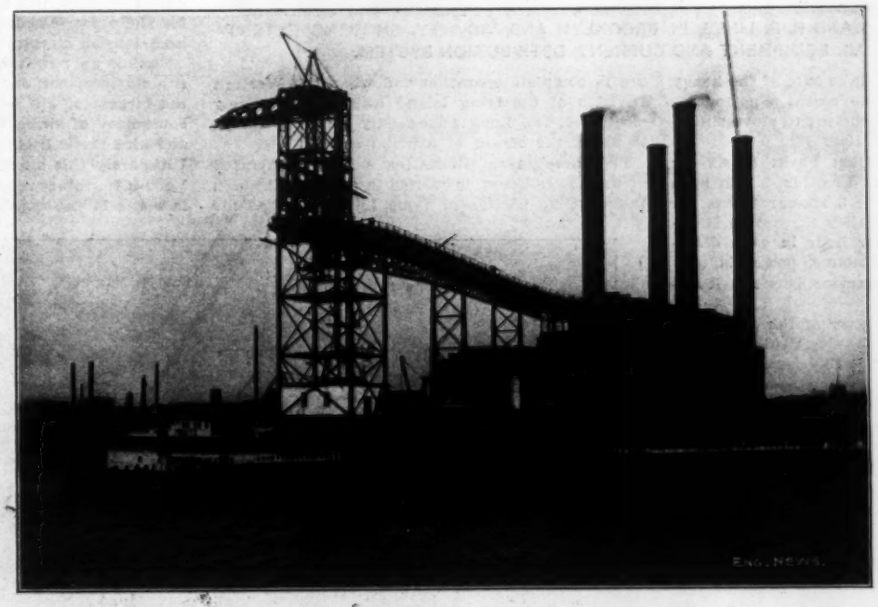
On agreement with the city, dated May 18, 1897, the railway company undertook to remove its tracks from the surface of Atlantic Ave., and to operate passenger trains on the line by a motive power not requiring combustion. This requirement obviously pointed to electric traction, and the planning of a satisfactory train service for this short section has resulted in the installation of the most extensive system of electrification yet put in operation on any steam railway in the world.

In the present article are described the main features of this important and interesting installation.

NATURE OF TRAFFIC.

As before stated, the Long Island Railroad at the extreme west end of the island consists of a network of lines having two important city terminals, and conducting a heavy through, as well as local, service. By reference to the map, Fig. 1, it will be seen that the Flatbush terminal is in the heart of the Borough of Brooklyn, and connects at that point physically with the Brooklyn Rapid Transit elevated lines leading to the Brooklyn Bridge, and to the Broadway Ferry; it will also soon connect with the subway and tunnels being constructed by the Interborough Rapid Transit Co. from the Battery, in the Borough of Manhattan, under the East River, and thence to Flatbush and Atlantic avenues. It will be seen that upon completion of the subway tunnel, passengers arriving at the Flatbush Ave. terminal, from points on Long Island, will have a short and direct route to the lower business section of Manhattan Island, by either the subway or by elevated lines over the Brooklyn Bridge. Furthermore, direct connection will be established by the elevated lines over the new Williamsburg Bridge.

The regular traffic on the Atlantic Avenue line comprises not only suburban trains carrying passengers from towns on the South and North shores of the island but also quite heavy local business from Flatbush Avenue out to Jamaica, and very heavy excursion business to Rockaway Beach and three different race tracks, located at Aqueduct, Metropolitan and Belmont Parks respectively.



VIEW OF LONG ISLAND R. R., ELECTRIC POWER HOUSE AT LONG ISLAND CITY TERMINAL.

EXTENT OF ELECTRIFICATION.

Considering the complicated train service above referred to, it was obviously impossible to adopt an electrification plan which contemplated electric haulage for part of the journey and steam haulage for the remainder of the journey to the principal points, beaches and race tracks, inasmuch as transfer of passengers en route to these points would occasion endless confusion and delay. It was therefore determined, in spite of the fact that immediate return on the very heavy outlay could not be expected, to electrify all lines leading out of the Flatbush Avenue Terminal upon which heavy suburban or excursion business took place. This resulted in the electrification of the suburban lines south of Atlantic Avenue and the main line out to Queens, and as far east on the Montauk Division as Valley Stream. It was not found necessary to electrify the line north of Atlantic Ave., as no through traffic from Flatbush Avenue to the terminal in Long Island City at present exists. When the tunnel lines to the Borough of Manhattan, now being constructed by the Pennsylvania Railroad Co., are completed, a new set of conditions will be introduced which will require very considerable extension of the electric service, and will no doubt comprehend at that time all the lines of the company for say 25 miles out of both terminals.

Inspection of the map accompanying this article will illustrate the present system of electrification, and its relation to the complete system.

The diverse character of the train service and its very fluctuating loading at different seasons of the year, due to the character of excursion business, formed a condition the reverse of favorable for economical electric traction, for the reason that the load factor on any of the fixed portions of the complete system as power house and transmission lines, would necessarily be a very low one throughout the year. In spite of this very great handicap, which meant an enormously heavy initial expenditure, the management of the railroad determined to provide complete electric service at the outset, having faith that the improved facilities afforded would result in the growth of the territory adjacent to their line, and in the end afford them a fair return on their investment. It must be confessed, however, that for the present, and probably for some time

to come, the expensive pioneering done by the company will result more in increased convenience to their patrons rather than in enlarged net revenues.

Under normal conditions the loading of the power plant and sub-stations will be comparatively light, but in order to take care of the heavy race track and excursion movement a power capacity has been installed sufficient to move simultaneously the following service:

Flatbush Avenue to Belmont Park: 15 six-car trains per hour in each direction. Flatbush Avenue to Rockaway Park: 3 six-car trains per hour in each direction. Valley Stream to Hammel: 2 four-car trains per hour in each direction. In addition to the above, power is supplied for the trolley car service between Rockaway Park and Jamaica.

A decision upon the character of the equipment and the characteristics of the electrical apparatus involved reference to the possibilities of connecting with the lines of neighboring companies, including the Brooklyn Rapid Transit Co., the Interborough Rapid Transit Co., and the Pennsylvania R. R. tunnels, as well as the physical character of the lines of the Long Island Railroad itself. In coming to a decision upon the work, therefore, operation over elevated lines, in subways, on the surface and also in the Pennsylvania Railroad Terminal and tunnels, had to be harmonized. It was decided, therefore, to adopt for the car equipment a type and dimension of car which would permit, if necessary, of through operation over connecting lines. It was also decided to adopt a system of electric distribution which was standard on connecting lines, namely: third rail contact and direct current at 600 volts for the propulsion current and alternating current transmission at 11,000 volts for conversion at sub-stations.

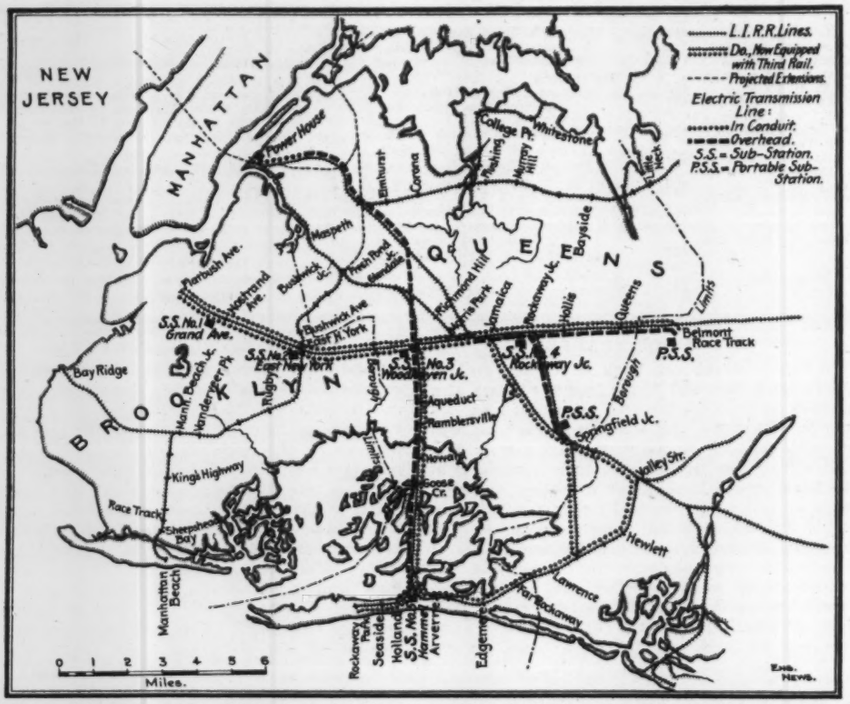


FIG. 1. MAP OF LONG ISLAND R. R. LINES, IN BROOKLYN AND VICINITY, SHOWING EXTENT OF THIRD RAIL EQUIPMENT AND CURRENT DSTRIBUTION SYSTEM.

THE DISTRIBUTION SYSTEM.

Current for the entire system will be generated at the large power house, now nearly completed, at Long Island City. This power-house will eventually be one of the largest in the world and has the distinction of being entirely equipped with steam turbines. There are at present installed three Westinghouse-Parsons turbine units, of 5,500 KW. capacity each, and the engine room provides facilities for three more such units. It will be noticed that this power-house does not stand at the center of gravity of the electrified system at present, but it must be remembered that the Long Island electrification forms a part of the general scheme for the operation of the Pennsylvania Railroad Terminal and the moving of trains in the North and East River tunnels. When all these improvements are in complete operation and when the Western Division of the Long Island Railroad is entirely electrified, the Long Island City location will be in about the center of distribution.

The three-phase alternating current, generated at the power-house, is carried in conduits through the built up portion of Long Island City as far as the railroad yards. From here the cables are brought overhead and carried on a specially designed lattice steel pole line. The construction of this pole line is most interesting and represents an advance over anything hitherto attempted in this direction. The poles are of ve... long construction and are mounted on co... foundations. Wherever the transmission l... cross telegraph or telephone wires, the la... led underneath the high tension wires. ...ry substantial character of the heavy ... cables precluding their breaking and fall... cross the telegraph wires. A further preca... is taken by having the poles placed closer t... at such points.

This pole follows the railroad tr... to Winfield, from which place it is led a... country on a special right-of-way to Glen... junction, where it again follows the railroad ... the sub-station at Woodhaven Junction. ... this point the lines branch off in the direction ... the different sub-stations.

In a transmission line of this kind ... bare wires are used, there is always a co... amount of danger to be feared from the eff... of lightning. This has been very carefu... guarded against in the present installation a... lightning arresters have been placed in all sub-... tions and special arrester and cut-out houses ... been erected at all places where the transmission wires are led from overhead and carried ... underground or submarine conduits and vice versa.

THE SUB-STATIONS.

The sub-stations are five in number and are located at the following places:

Sub-station No. 1.—Grand and Atlantic Avenues, Brooklyn.
" " " 2.—East New York.
" " " 3.—Woodhaven Junction.
" " " 4.—Near Rockaway Junction.
" " " 5.—Hammel.

It will be noticed that as far as possible sub-stations have been located at junction points, such points being more practicable, as they are the points at which the heavy loads occur. Such locations also make it possible and convenient for the arrangement of transfer switches for the high tension circuit.

Taking up now the equipment of the different sub-stations, the one at Woodhaven Junction is the largest of all, being provided with an initial equipment of three 1,500 KW. rotary converters and nine static transformers of 550 KW. capacity. Ultimately this station will be equipped with six 1,500 KW. rotary converters with a corresponding increase in the number of static transformers.

FIG. 3. WESTINGHOUSE-PARSONS STEAM TURBO-ALTERNATORS OF 5,500 KW. CAPACITY IN LONG ISLAND CITY POWER HOUSE.

The Grand Avenue sub-station is provided with an initial equipment of three 1,000 KW. rotary converters and nine static transformers of 375 KW. capacity. The ultimate capacity, however, will include four 1,500 KW. rotary converters

with a corresponding increase in transformer capacity.

It might be said here that all these sub-stations, which are now equipped with 1,000 KW. rotary converters, are provided with foundations of sufficient size to accommodate converters of 1,500 KW. capacity. The idea is that as soon as the present sub-stations reach their maximum

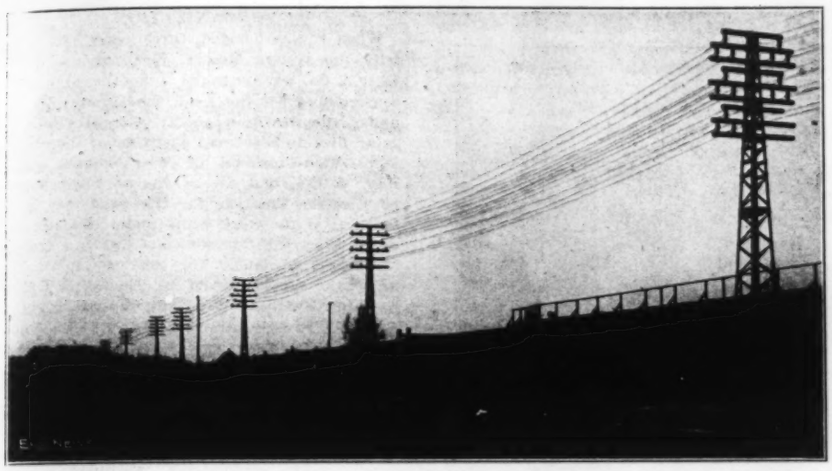


FIG. 4. TRUNK TRANSMISSION LINE BETWEEN LONG ISLAND CITY AND WOODHAVEN JUNCTION.

capacity with 1,000 KW. converters, the sections of railway, electrically equipped, will have extended far enough to warrant the building of more sub-stations further out on Long Island. It will therefore be possible to move the 1,000 KW. converters from their present stations to the outlying ones and erect in their place converters of 1,500 KW. capacity.

The Rockaway Junction sub-station is provided at present with an initial equipment of two 1,000 KW. rotary converters and six static transformers of 375 KW. capacity. The ultimate equipment will include four 1,500 KW. rotary converters and the proper number of static transformers.

The East New York sub-station has an equipment of three 1,000 KW. rotary converters with nine 375 KW. transformers, while the ultimate equipment will consist of four 1,500 KW. rotary converters and the corresponding number of transformers.

The sub-station at Hammel is equipped with two 1,000 KW. rotary converters and six 375 KW. transformers. Ultimately, however, it will contain six 1,500 KW. rotary converters with a corresponding increase in transformer capacity. In addition to the above, this sub-station is provided with a storage battery of 2,000 KW.-hours capacity, making it the largest storage battery in the world in use for electric railway work. Its installation was deemed expedient owing to the fact that the Hammel sub-station is the farthest from the power station and the transmission line is exposed to an unusual extent, being carried over Jamaica Bay for four miles. Furthermore the load at Hammel is very light during the winter and the very large battery capacity makes it practicable to shut down the rotary equipment for much of the time during the winter months.

In external appearance all these sub-stations very much resemble each other, being built of brick and steel and of fireproof construction throughout. They also conform closely in interior arrangement, the rotaries and transformers being set up on the first floor, while the main switchboard is placed in a gallery on one side of the building, from which the operators have an uninterrupted view of all the machinery under their control. The high tension cables are led to a carefully insulated board on the other side of the building facing the main switchboard.

Before leaving the subject of sub-stations, it might be well to mention that all of them are provided, on emergency, with the means of augmenting their capacity to the extent of 1,000 KW. through the use of portable sub-stations. These consist of steel cars, each carrying a 1,000 KW. rotary converter and three static transformers. Two such portable sub-stations have been built. They were designed primarily, not only to reinforce the permanent sub-stations, but to maintain the potential at any points where traction might, temporarily, be very heavy. Such conditions would be met at the different race tracks, and therefore buildings have been provided at Belmont Park race track and at Springfield Junction, near the Metropolitan race track, where these portable sub-stations may be housed and connected up.

While the use of portable sub-stations is not new, yet it is interesting to know that they are being used on a larger scale in this installation than has ever before been attempted. One reason for their extensive use is found in the fact that no feeders are used for supplying the third rail, the high conductivity of these rails permitting of dispensing with feeders for all ordinary conditions of traffic.

THE THIRD RAIL.

Direct current, at a potential of 600 volts, is led directly to the third rail from the different sub-stations. Great care is being taken with this third rail installation to guarantee the safety of pedestrians and no expense has been spared to attain this result.

The rail is laid at the standard distance from the track rail adopted by this road, the Pennsylvania R. R. and the Interborough Rapid Transit Co., namely, 27 ins. from the gage line of the track to the center line of the third rail, and with top of rail 3½ ins. above the top of the track rail. Placing the third rail in this position will allow of interchange between the above-named railroads, and will permit of proper clearances for steam equipment, especially the steel hopper cars now in general use.

The rail is laid on long ties, which extend at intervals beyond the line of track, and is supported by insulators made of vitrified clay. It is covered throughout its entire length by a wooden sheathing held in place in the following manner. Brackets of steel attached to the rail are firmly bolted to wooden uprights outside the rail, and to these, by separate bolts, are attached a second set of strong brackets supporting a plank 2 ins. thick and at a height of about 4 ins. above the rail. Wherever the rail is led in front of stations a special side sheathing is attached to both sides, making it practically impossible for pedestrians to come in contact with it. Another feature in connection with the protection of passengers at stations is the fact that a running board, similar to the one covering the third rail, is led along the outside edge of the platform and effectually prevents passengers from coming in contact with the collector shoes of the motor cars.

At either side of a grade crossing the third rail terminates in a broad sloping shoe, similar to that at switches and crossings on the New York Subway and Elevated lines. This is considerably within

FIG. 5. PORTABLE SUB-STATION CARS AND CONCRETE HOUSE FOR RECEIVING THEM AT BELMONT PARK RACE TRACK.

the line of protecting fences, which enclose the entire right-of-way, and a heavy insulated wire cable connects it with the third rail, similarly situated beyond the break. The cable passes underground in a concrete duct situated at a depth not likely to permit of interference by crossing repairs.

The total mileage of third rail installation reduced to a single track basis is 97½. This is divided up in the following manner: Miles of main line equipped, 42; main line single track mileage equipped, 90; sidings, 7.5.

FIG. 6. TERMINAL AT BELMONT PARK, SHOWING UMBRELLA-ROOFED PLATFORMS AND THIRD RAIL.

TRAINS.

The trains are made up of steel motor cars (of which 130 have already been equipped) and trailers in the ratio of three to two; that is, a five-car train will consist of three motor cars and two trail cars, the motor cars being cars 1, 3 and 5. An eight-car train, however, will consist of five motor cars and three trail cars, the motor cars being 1, 3, 5, 6 and 8, or else numbers 1, 3, 4, 6 and 8.

All the cars are equipped with the Westinghouse Pneumatic Multiple-Unit System of control, and each motor car has two propelling motors of 200 HP. each, both of which are carried on the same truck; that is, each motor car has a motor truck at one end carrying two motors, one geared to each axle, while the truck at the other end of the car is a "trailer," and carries no motive power. Both cars and trucks were designed by Mr. Geo. Gibbs, Chief Engineer of Electric Traction for the Pennsylvania, New York & Long Island R. R., and for the Long Island R. R., and were built by the American Car & Foundry Co., and the Baldwin Locomotive Works, the cars being constructed by the former company and the trucks by the latter.

These cars are quite similar in appearance to the steel cars in use in the New York subway (which were also designed by Mr. Gibbs), being constructed throughout of steel and finished in aluminum. The problem of their design has been considerably simplified through the experience already gained with the subway cars. The requirements of the Long Island Railroad, however, necessitated the embodying of a good many special features in order to conform to the requirements of the service. For instance, all the conditions and limitations which applied to the New York subway, such as limited subway heights and clearances on curves, high speeds with frequent stops, maximum strength combined with smallest possible weight, etc., applied with equal force to the Long Island problem since the Long Island cars were designed to interchange with the cars in the Manhattan subway. An additional feature presented itself, however, in the fact that trains, after leaving the city limits, had to run on the ground and let passengers on or off at stations whose platforms did not come flush with the platforms of the cars. This necessitated the design of a special combination platform which should be the full width of the car when running within the city limits, but which would provide for a pair of steps to be used when running on the surface of the ground.

These cars are now receiving their equipment at the shops of the Long Island Railroad between Locust Avenue and Springfield on the cut off line to Valley Stream. The shops have a capacity for the equipment of about ten cars per week, which are received from the builders in an entirely completed condition as regards exterior and interior finish, but are bare of any electrical apparatus. After receiving their electrical equipment they are given many trial runs before being placed in active service. Each motor car weighs 83,000 lbs. and is capable of maintaining a maximum speed of 55 miles per hour and a schedule speed, including stops 1.6 miles apart, of 25 miles per hour.

A noticeable feature of their operation is the fact that, although attaining their maximum speed under very short headway, there is no jerk or jar experienced in the process, acceleration being accomplished very smoothly and evenly. The trains are brought to a stop in the same even manner, being equipped with specially designed air brakes controlled by the new Westinghouse graduated-release triple valve. In this respect the equipment is a great improvement over any electric trains hitherto tried.

In order that the rolling stock of the road be kept to its full efficiency large car inspection sheds have been erected at Rockaway Park, Dunton and at the Morris Park shops. The one at Rockaway Park being 100 × 30 ft. in size, the Dunton shed 200 × 50 ft., and the one at Morris Park 200 × 75 ft. These sheds are large enough to accommodate trains of eight cars and are fitted with all necessary tools and appliances, the pits being fitted with compressed air plant in order that pneumatic tools may be used under the cars.

ORGANIZATION.

When it was decided, three years ago, to electrify the system Messrs. Westinghouse, Church, Kerr & Co. were engaged to act as engineers and constructors for the road, the entire work being under the direction of Mr. George Gibbs, who acted first as Electrical Engineer of the road and First Vice-President of Westinghouse, Church, Kerr & Co., and afterwards as Chief Engineer of Electric Traction for the road, the general features of the work being under the supervision of the Electrical Committee of the road, composed of various officials. The construction work was under the supervision of Mr. George B. Caldwell, who acted as Superintendent of that department.

Work was begun on the various sections as follows: Power-house, September 15, 1903, the first engine being put in operation January 6, 1905, and regular operation was commenced July 26, 1905. Work on the sub-stations was begun May 24, 1904, and completed July 7, 1905, the sub-stations being put into operation July 26, 1905. The transmission system was started November 30, 1904, and finished May 27, 1905, while work on the third rail and the bonding of the tracks was begun October 6, 1904, finished August 31, 1905, and put into operation July 26, 1905.

RAILWAY RATES; AN EXPERIMENT IN RATE-MAKING ON AN INTERURBAN RAILWAY.

By Wm. D. Marks, M. Am. Inst. E. E.*

With the growth of the electric railway into long roads connecting towns, the question of rates of fare and freight becomes one demanding attention, particularly since many electric railways are competing with parallel steam roads for passengers and sometimes freight.

Besides charging a regular long-distance-passenger rate steam railways make large concessions or rebates to excursionists and commuters.

FIG. 7. HIGHWAY GRADE CROSSING NEAR WOODHAVEN JUNCTION, SHOWING THIRD RAIL TERMINALS.

The excursionists are regarded by them as so much gain in income, as without special rates their fares would not be obtained by the railway. The custom is to transport them on extra trains in well-filled cars and so obtain a profit. The commuter travelling every day furnishes a regular business for which well-filled cars are used, and for this reason is carried at a very large

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rebate. In the matter of freight the steam railways also make it a principle to carry freight long distances at a very much lower rate than for short hauls, and they also indulge in arbitrary classifications of freight which often bear no proper relation to the cost of hauling.

In general the steam roads do not endeavor to make a profit on passenger traffic but they do make a very large profit on freight traffic. No detailed information as to actual costs of the construction, equipment or operation of steam railways can be obtained (from their reports to the Interstate Commerce Commission) which would serve our purpose in a minute and candid investigation, and so the figures used will be the practical figures of a single track electric railway 50 miles long equipped for both freight and passenger traffic in a western state.

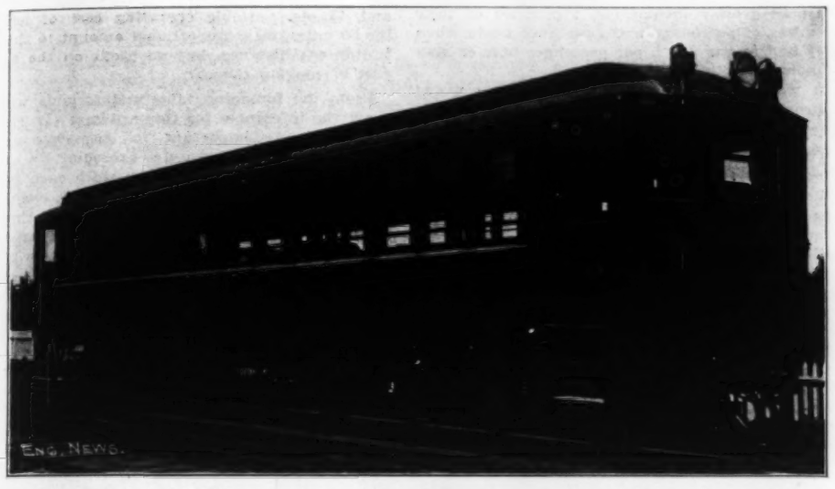

FIG. 8. STANDARD STEEL MOTOR CAR, LONG ISLAND R. R., SHOWING PROTECTION OF CONTACT-SHOE.

In order to state the various points of view generally and succinctly it will be necessary to make use of algebraic symbols—

Let f = fare per passenger mile or freight per car-mile.
" m = number of miles of single fare or freight car.
" F = fixed operating expenses, annual total.
" H = total annual passenger-hours or car-hours.
" h = number of passenger-hours or car-hours for single fare or freight.
" O = total annual variable operating expenses.
" M = total annual passenger-miles or freight car-miles.
" $o = \frac{O}{M}$ = variable operating expense per passenger, or per freight car-mile.
" % = percentage on investment covering taxes depreciation, interest, and profit.
" C = total investment in the constructed and equipped railway.
" r = ratio of passenger-miles or ton-miles to car-miles.

We can then write the equation fixing the fare or freight for a single trip as follows:

$$fm - \left[\frac{F}{H}h + mo\right] = \frac{\%C}{H}h$$

fm = the passenger fare or freight charge for m miles.
$\frac{F}{H}h$ = the proportional fixed operating expenses for h hours.
mo = variable operating expenses for m miles.
$\frac{\%C}{H}h$ = percentage of investment for h hours.

We observe that the passenger fare equals the sum of three factors.

Taking the quantities from the electric railway in question, which cost $1,000,000 cash assumed to be equally divided between freight and passenger traffic, and considering passengers, we have

C = $500,000; F = $23,160; H = $262,800; % = 15; o = 0.9 cent.; r = 10;

and assuming an average speed of 25 miles per hour and a trip of 50 miles, we have

h = 2 hrs.

$\frac{\%C}{H}h$ = 57.0 cents.
$\frac{F}{H}h$ = 17.6 "
mo = 45.0 "
fm = 119.6 "
f = 2.4 " per passenger mile.

If we assume the average speed to be the same for all distances and cars we must charge 2.4 cts. per passenger-mile unless we can increase r and thereby the number of passengers, or else their average length of trip; or the number of freight cars and their length of trip—the latter requiring an increase in H and M.

In the formula just stated we assume that 15% must be paid by each passenger for his pro rata share (fixed by hours of occupancy) of the investment placed at his disposal, and the actual variable cost per mile of transporting him, and also his pro rata share of the fixed operating expense. The transportation, o m, is fixed at cost and the profit is proportioned to hours of occupancy. As the transportation costs (9 cents per car-mile) ceases with movement of cars while fixed expenses and investment charges do not, this is often considered a judicially fair method of fixing fares. However, it might be worth while as a check to investigate the method of charging a profit proportioned to the miles of transportation and fixing fares in this way. Our equation can then be written

$$fm - \left[\frac{F}{M}m + om\right] = \frac{\%C}{M}m$$

and we have

$$f = \frac{\%C}{M} + \frac{F}{M} + o$$

Since M = 657,000 car-miles or 6,570,000 passenger-miles, this gives f = 2.40 cts. per passenger mile.

It is evident that an apparently judicially impartial statement of our problem leads to the same result whether we use passenger-hours or passenger-miles, because we have assumed an average speed of 25 miles per hour. This would indicate that the mutual obligations of railway and patron are measured entirely by the distance of transportation in each instance.

But this is not our case. This new railway has greatly increased the value of the lands which it serves and has also reduced and shortened the cost and time of travel and transportation. For this reason all residents in its vicinage owe something more than their pro rata share of carfare and freight to this new railway which has within its year of operation caused a rise of 10% or more in the price of lands and town property which it serves, and has largely reduced the cost of travel and freight shipments on the competing steam railways. This moral obligation, however, since the completion of this railway is not recognized, and wherever possible the residents avail themselves of the very low competing passenger and freight rates since offered by two steam railways which at points 15 and 50 miles from the metropolis (to which all roads run) are competing for both freight and passengers reckless of their own losses in the effort to crush the weaker electric railway.

During the past year this electric railway has charged 2 cts. per passenger-mile and obtained a ratio of about 10 passenger-miles per car-mile. It is now endeavoring to average 1½ cts. per passenger-mile and obtain a ratio of 16 = r. It has also altered its freight rates as well as passenger rates, offering very much lower rates for long hauls, and while doing this to meet competition still is hoping to obtain a lump sum for each passenger or patron which will liquidate the many forgotten promises made to the promoters of this railway before its construction.

However incapable of numerical measurement, my fair-minded readers will agree with me that this obligation does exist and should honorably be paid by resident passengers and freight shippers along the line of this railway. This principle is very well exemplified by the method of charging a lump sum each month used by telephone companies for minimum payments..

This obligation, however, being a lump annual sum should be divided fairly among this resident class of travelers and patrons and for that reason it is just to divide it among the passengers in proportion to their numbers regardless of the distances which they may find it necessary to travel to reach the metropolis. The same obligation does not apply to non-resident or occasional travelers, and a rate of 2½ cts. per passenger-mile should when competition permits be charged to them.

As fixed operating expenses and fixed charges do not increase with the increase of passengers or freight, in this case it is intended to use every expedient to create a desire to travel and to gain the patronage of the public served. With this much of generalization we take this railway under consideration in detail.

PASSENGER COMMUTATION AND FARES.

For the sake of simplicity, round figures substantially the same as the actual are used for this interurban electric railway, which was built under the assumption of about equal gross earnings from passenger service and local freight service. The passenger service is fixed at hourly intervals, using four going cars averaging a speed of 25 miles per hour, including stops.

One-half the cost of construction and equipment of this road is therefore chargeable to the passenger department. For this 50-mile single track, equipped with both passenger and freight cars, the cost is $1,000,000; annual depreciation, 7½%, or $75,000; annual taxes and profit on investment, 7½%, or $75,000. One-half of these sums must therefore be cared for by the regular earnings of four going passenger cars, as any extras from excursions may no more than care for unexpected expenses unless the road is unusually fortunate. To cover the passenger department's profit, taxes and depreciation the net earnings of each of the four cars must be $18,750 annually.

These cars if operated at the speed fixed (25 mi. per hr.) for 18 hours each day (450 car-miles), will make 164,250 car-miles annually, and the operating cost per car-mile being found to be an average of 12½ cts., will amount to $20,531.

Thus we have, for one car:

Operating cost, per year	$20,531
Taxes, profit and depreciation per year.	18,750
Gross earnings required	$39,281

If we divide the gross earnings by 164,250 car-miles, we find that the required gross earnings are nearly 24 cts. per car-mile.

Now, the average earnings of interurban railways throughout the United States are 21¼ cts. per car-mile, or 2¾ cts. less, and this, moreover, with cars run usually less than one hour apart.

We observe that the operating expense per car-mile, 12½ cts., cannot be lowered in the present state of the art of electric railway construction and operation, and further, that taxes, profit and depreciation require that 11½ cts. more per car-mile be earned to make a gross earning of 24 cts. The cars of this railway seat 50 persons, and must, if Western averages obtain, average a load of 12 persons, at 2 cts. per car-mile, to earn 24 cts. This concession in price below the 3 cts. of steam railways is frequently said to be sufficient to obtain all the passenger traffic there is, but in this case commutation on steam railways has prevented this result.

Under the above assumptions each fare paid about 1 ct. per passenger-mile for operating expenses and 1 ct. for profit, taxes and depreciation. But experience has proved that our average load is not quite 10½ persons at 2 cts., and gross earnings are 21 cts. or less per car-mile.

To offer reduced rates without obtaining an increase of the number of travelers is only to reduce this road's gross earnings. This is a disastrous experience which has been tried on Indiana interurban railways; they reduced the price per passenger-mile to all travelers until, reaching 1 ct., they found that their gross earnings had so fallen off as to require a return to a basis of 1½ cts. per passenger-mile for fares in order to earn the interest on their bonded debt. The task for our railway manager then is how to make such concessions to regular riders as will increase their number, and, while making this concession, prevent a falling off of the gross earnings of his railway.

Clearly the taxes, profit and depreciation ($18,750) for each car must be earned if the road makes a profit, and the operating expenses ($20,531) for each car remains the only factor for consideration. Long experience has proved that this aggregate cannot be reduced and proper service rendered. There remains then only the expedient of placing this expense upon the fares more equitably than has heretofore been the custom at a straight 2 cts. per passenger-mile, and in doing this availing ourselves of the principles which our telephone companies have adopted.

Examining the operating expenses of electric railways more closely we find that they can be roughly divided as follows:

Fixed operating expenses independent of the car-miles:		
Maintenance of way and structures	8.5%	
Miscellaneous expenses	18.2 "	
Electric service	1.5 "	28.2
Variable operating expenses, varying with the car-miles:		
Maintenance of equipment	11.7%	
Operation of power plant	16.2 "	
Operation of cars	43.9 "	71.8
		100.%

In round figures we may say, for each car:	
Fixed operating expense	$5,790
Variable " "	14,741
Total " "	$20,531

The fixed operating expenses do not increase with the mileage of the car, and therefore should be charged as a lump sum to each car ($5,790 each year). The variable operating expenses ($14,741) obviously do increase and decrease with the mileage, and give a cost per car-mile of nearly 9 cts. We will take 2 cts. per car-mile and 10 passengers as the existing average, giving 20 cts. gross earnings per car-mile. From observation the average length of trip on this road is one-fourth the length of road, or 25 cts, fare (there are no blocks). Each car-mile equals 10 passenger-miles and four fares are required for each round trip of 50 miles. Our passengers in one year are 1,642,500 ÷ 12.5 = 131,400 per car.

In order to find the proper lump sum to be charged to passengers we add together:

Taxes, profit and depreciation per car.	$18,750
Fixed operating expenses	5,790
Total of fixed expenses and charges	$24,540

Dividing this by 131,400, we obtain 18.7 cts. as the fixed sum justly chargeable to each passenger residing on the line who avails himself of this railway as a public convenience, no matter what the length of his trip may be. The assumption is made that the passenger is generous enough and wise enough to wish the owners of this railway to make a moderate profit and to care for taxes, fixed operating expenses and depreciation (since it is built and operated for his convenience) each time he makes use of this railway. From previous figures we see that the passenger should also pay for the variable operating expense per passenger-mile, or nine-tenths of a cent (0.9 ct.) per mile for the distance of his trip. Each commuter makes two trips daily and represents two passengers, and should pay 37.4 cts. as a minimum fare to cover his share of fixed expenses and charges. Remembering that our figures can only be rude approximations, we have then the following fare table for the past year, for r = 10.

COMMUTERS' FARE TABLE.
Based on One Year's Operation.

				Per passenger mile.
For 10 miles	37.5	+ 9	= 46.5 cts., or	4.65
20	"	+ 18	= 55.5 "	2.77
30	"	+ 27	= 64.5 "	2.15
40	"	+ 36	= 73.5 "	1.84
50	"	+ 45	= 82.5 "	1.65
60	"	+ 54	= 91.5 "	1.52
70	"	+ 63	=100.5 "	1.43
80	"	+ 72	=109.5 "	1.36
90	"	+ 81	=118.5 "	1.31
100	"	+ 90	=127.5 "	1.27

One hundred miles represents a complete round trip of the length of the road.

The rate situation is this: Two competing steam railways are competing to the metropolis at 1½ cts. per passenger-mile at points 50 and 15 miles distant from it; that is, they are selling excursion and commuters' tickets at one-half their regular former rate of 3 cts. for distances of 18 and 65 miles.

It is easy to see from the table that the electric railway would find it possible to reduce 100-mile round trip tickets to $1.27, provided it could raise its shorter trip excursion and commuters' tickets of less than 60 miles to a just figure, as shown in our table. But this is not a feasible, although we think it is a just, arrangement; for the public would insist that such an arrangement of fares must be grossly inequitable, regardless of their promises of patronage and assistance made when they had to pay 3 cts. per passenger-mile or stay at home.

It was anticipated that each going car would approximately return gross earnings as follows:

164,250 car miles × 12 passengers @ 2 cts. per mile $39,420

The actual result is nearly

164,250 car miles × 10 pass. @ 2 cts. $32,850

Long distance travel on the electric railway has not been up to expectation, while short distance trips have exceeded it. True, the steam railways have somewhat increased their regular losses on passenger traffic, but this is to them a small matter, to be recouped in freight profits when the electric railway is crushed. The electric railway managers are aware of two advantages: (1) Their cars travel every hour of the day (at the rate of 25 miles, against 30 miles per hour on the steam railway), and (2) they have as yet only reached one-fifth of their average capacity, while the night and morning trains of the steam roads are few and crowded.

The electric railway has therefore adopted the following suggestions and conditions: (1) Carries passengers in city limits at 5 cts., as required by franchises (the greatest distance is 2 miles); (2) charges 2½ cts. per mile for all single trips regardless of distance, which makes $1:25 for 50 miles, the highest fare on the road; (3) Sells two-day excursion round-trip tickets at 1½ cts. per passenger-mile for all distances greater than 10 miles; (4) sells thirty-day 30 round-trip family commutation tickets at 1½ cts. per passenger-mile for all round trips of 60 miles or less down to 10 miles, good for all inmates of purchasers' household at any time within 30 days; (5) sells family commutation tickets for over 60 miles at figures given in table above.

In some cases a family has already used up a 30-day ticket in a week. No increase of speed has been attempted, and yet the commutation tickets have greatly increased the long distance (over 60 miles) travel within the past 30 days of trial. The conductor does the ticket selling and punching, ringing up 5-ct. fares in city limits only.

The aim of the manager is to increase the number of passengers, and particularly to obtain regular long distance daily travelers from point to point, the assumption being that the increase of operating expense will be nothing with 20% increase of the last year's earning results, and that occasional single trip travel will not be reduced by a 2½-ct. rate.

Using the abbreviations of algebra, we can state our case as follows for passenger traffic, as numerically given in the previous table:

C = Allotted cost of operative railway (half cost)	= $500,000
P = Annual number of passenger fares (one for each trip)	= 525,600
$\frac{C}{P}$ = investment for each passenger's use	= 0.951
% = percentage covering profit, depreciation and taxes	= 15
$\frac{\%C}{P}$ = profit, depreciation, and taxes, per passenger	= 0.143
r = number of passenger-miles per car-mile	= 10
F = fixed annual operating expenses of railway	= 23,160
$\frac{F}{P}$ = fixed operating expenses per passenger	= 0.044
o = operating variable expense per car mile.	= 0.09
m = passenger miles of any given trip passenger.	
f = fare per passenger-mile required.	

We can write our equation of profit as follows:

$$fm - \left[\frac{F}{P} + \frac{o}{r}m\right] = \frac{\%C}{P}$$

If we arbitrarily fix m = 50 miles, we have

$$f = \frac{\%C}{Pm} + \frac{F}{Pm} + \frac{o}{r} = 1.27 \text{ cents.}$$

Here fm, fare paid = 63.5 cts., is divided as follows:

Share of fixed operating expenses	$= \frac{F}{P}$ = 44
Share of variable operating expense	$= \frac{o}{r}m$ = 45
Profit, depreciation, and taxes (share)	$= \frac{\%C}{P}$ = 143
	637

This statement assumes that each person whenever he becomes a 50-mile passenger pays the sum of 18.7 cts. for fixed charges and expenses, and 45 cts. variable operating cost of hauling for 50 miles, or a proportional amount to this for a different distance, but no profit on the actual cost of moving the car.

From the foregoing table and formula we can draw the inferences for this railway: (1) That it is exceedingly important to encourage excursion trips and commuters exceeding 60 miles round trip by proper rebates, since each excursionist make two passengers and each commuter 720 passengers per year. By thus increasing the number of passengers, we reduce the fixed expenses and charges required per passenger.

(2) That 5-ct. fares in the city limits appear to require five or six times the present average passenger traffic per mile of the whole road to become profitable to it from this point of view.

(3) From the table we can learn that a passenger who travels 5 miles at 4.65 cts. should theoretically pay 23¼ cts., and thus would pay the railway 18.7 cts. to cover fixed expenses and charges and 4.5 cts. to cover variable operating cost, while a traveler for 50 miles should pay 63.7 cts. total, or 45 cts. variable operating cost and 18.7 cts. fixed expenses and charges. The surplus to the railway is 18.7 cts. in each case.

The usual method of fixing rates is to endeavor to fix the fare per passenger-mile at a *uniform* figure, such as will at the end of a year produce the required fixed charges and operating expenses. In this case the total passenger-miles is 6,570,000, and the total of fixed and operating expenses, $157,124; therefore the fare per passenger-mile required is 2.39 cts. The standard rate of fare in our case has therefore been fixed for single trips only at 2½ cts. per mile.

Passengers for a lesser distance than 12½ miles do not pay their proper share toward the support of our railway, if our assumption is right. Obviously, too, those riding more than 12½ miles would, at 2.4 cts. per passenger-mile, have to pay more than their rightful pro rata of profit for this railway.

The basis of these assertions is this principle:

Each local passenger ought of right to guarantee a fair profit at a fair rate for the support of any public service institution of whose conveniences he avails himself and all should alike pay this in addition to the actual cost of service rendered, and particularly do so in this case, because of the great reduction in cost of travel brought about by this railway. Any quasi-public institution, operated at a loss, is of no permanent value to the community, and may become a serious injury to it by failure.

To overcharge local long distance riders for the purpose of enabling short distance riders to travel for less than cost is inequitable, and this is done when fares are fixed at an invariable price per passenger-mile for all distances, for the variable part of the transportation cost is but a fraction of the total yearly cost of operation of any railway. Because, however, of the superficial reasoning and prejudices of the traveling public and of unintelligent competition it has finally been deemed necessary to vary from the commuting table of fares above calculated for this railway, fixing 5-ct. fares for towns; 2½ cts. per mile for single trips; 1½ cts. per mile for excursions and commutation under 60 miles; and commuters' rates, as previously tabulated, for all commuter tickets above 60 miles per day.

There is a limit, however, to gross passenger earnings beyond which no ingenuity of finance or offered inducements to travel can raise them. A careful examination of the resources and popu-

lation of the field served and an estimate made by means of comparison with existing interurban railways (of more frequent service usually), of like length, at 1½ cts. straight per passenger-mile, has made the annual estimate for gross earnings $35,168 total, or $33,792 per operating car. However, the existence of a rapidly-growing metropolis on this line offers an inducement to travel which warrants the belief that an annual gross earning of $39,420 per car can be reached with proper management. This feature of the line's location further requires the arrangement of our figures on a different basis from that generally adopted.

It is believed that this action, while reducing the cost per passenger-mile to about 1½ cts., will increase the ratio of passenger-miles to car-miles to 16 = r, and the earnings per car-mile to 24 cts. Notwithstanding the steam railway competition, it has more than done so for the 30 days of July, which has greatly reassured the management. Winter travel has not yet been tested.

FREIGHT RATES.

When making the preliminary estimate of freight earnings through that part of this country as yet unfurnished with a railway, it was found impossible to determine the number of carloads received by it, although a careful canvas of a strip five miles each way from the railway's location predicted about the following data of outgoing freight very closely, both as hauled in wagons or driven on foot and shipped out on the comparatively distant steam railways in one year:

Outgoing Freights to the Metropolis.			
Live stock	2,442 carloads @	$12.00	$29,304
Farm products	3,483 carloads @	16.00	55,728
Dairy products	405 carloads @	30.00	12,150
Fruit products	138 carloads @	20.00	2,760
	6,468 carloads @	15.45	$99,942
Incoming freights 4,550 carloads			$72,800
Express and lighter freights			12,200
Total earnings			$184,942
Total freight car mileage (loaded and unloaded)			550,900
Gross earnings per car-mile			33½ cts.
Operating expense per car-mile			20½ cts.
Net earnings per car-mile			13 cts.

For handling this freight, three 200-HP. electric locomotives, one 300-HP. second-hand steam locomotive, and 30 box freight cars of 36-ft length were used and charged to freight-car mileage.

In making freight rates this railway adopted the same rates as the two steam railways which it intersected at points 15 and 50 miles from its metropolis, where it delivered its own freight to the "Belt Line," which, fortunately, is obliged under its charter to take all freight. The steam railways will not make through freight contracts with this electric railway, but the latter has arranged with them to haul their loaded cars to and from consignees on its line at regular local rates. Adding an average of two foreign cars makes 32 freights usually in use on this railway.

Using the briefer algebraic terms, we have the following data:

C = estimated cost of complete railway (half total) $500,000
P = annual carloads handled 11,018
C/P = investment per carload handled $45.83
% = percentage covering profit depreciation and taxes.
%C/P = profit, depreciation and taxes per carload handled.
F = total fixed annual operating expenses $19,281
F/P = fixed operating expenses per carload $1.75
O = variable operating expense per car-mile ... $0.17
m = car-miles for any given shipment.
f = freight rate per car-mile (gross earnings) .. 33⅓ cts.

The formula is, $f\,m - \left[\frac{F}{P} + m\,O\right] = \frac{\%C}{P}$,

For a car of freight to middle of line (back empty) we have $f = 33\frac{1}{3}$ cts.; $m = 50$ miles; $\frac{F}{P} = \$1.75$; $o = 17$ cts.; $\frac{C}{P} = \$45.83$; therefore, % = 14.2. Fourteen per cent. profit, taxes and depreciation leaves 5% net profit on investment for this carload of freight.

From 6 to 60 carloads per day, mostly hauled after midnight, have kept the four locomotives very busy at times, and interfered somewhat with the passenger service on this single-track railway during rush periods, but no collisions have occurred owing to the use of a simple three-wire block signal system from switch to switch.

If we accept 14.2% of the investment per carload as the basis of our formula, we can write an equitable system of freight charges per car-mile, remembering that as the car is empty one-half the time, and nearly all freight is either obtained or delivered at the metropolis at one end of the line, the rate must be doubled and the distance halved in the bill presented.

TABLE OF CORRECT FREIGHT RATES PER CAR-MILE.
On Basis of 14% Net Earnings.

10	miles	round	trip	Rate	per	car-mile	$0.993
20	"	"	"	"	"	"	0.582
30	"	"	"	"	"	"	0.445
40	"	"	"	"	"	"	0.376
50	"	"	"	"	"	"	0.335
60	"	"	"	"	"	"	0.307
70	"	"	"	"	"	"	0.288
80	"	"	"	"	"	"	0.273
90	"	"	"	"	"	"	0.262
100	"	"	"	"	"	"	0.253

It is obvious from this tabulation that freight hauled five miles should have been charged four times the rate for a 50-mile haul in order to share support of this railway equitably amongst its patrons. The argument made previously for passenger rates holds with even greater force for freight rates, since the railway is obviously a far greater convenience for freight than it is for passenger service.

The existing net profit from freights is altogether too small, due to the fact that the majority of service rendered is for short hauls, for which the rates must be raised. No attempt to raise all rates by a percentage of the existing rate can wisely be made; it would only aggravate the existing evil of short hauls. The rates for long hauls appear too high, and money is steadily being lost in short hauls. Time lost in loading and unloading, and terminal payroll and services, increase the discrepancy. Twenty per cent. for taxes, depreciation and profit should be striven for.

The following table is computed on a 20% basis as a general guide in alterations of present rates, as fixed by the Board of Directors. With few exceptions space occupied in car rather than weight must be considered where the existing rates on steam railways do not fix the freight charges by competition.

TABLE OF CORRECT FREIGHT RATES PER CAR-MILE.
On Basis of 20% Net Earnings.

10	miles	round	trip	Rate	per	car-mile	$1.26
20	"	"	"	"	"	"	0.715
30	"	"	"	"	"	"	0.534
40	"	"	"	"	"	"	0.442
50	"	"	"	"	"	"	0.388
60	"	"	"	"	"	"	0.352
70	"	"	"	"	"	"	0.326
80	"	"	"	"	"	"	0.306
90	"	"	"	"	"	"	0.292
100	"	"	"	"	"	"	0.279

This table is computed under the assumption that each carload should pay a lump sum of $10.91 to cover taxes, depreciation, maintenance of way and structures, miscellaneous office expenses, salaries, legal services, advertising, printing, insurance, rentals, damages, electric expert services, and, finally, interest and profit, if there is any (these quantities are not in proportion to car-miles run, but may be said to be in proportion to the investment made); and 17 cts. per mile for moving of cars, which is actual cost of maintenance of equipment, operation of power plant and of the freight cars and locomotives, these latter items being assumed to be proportionate to the car-miles run. No profit whatever is made on the charge of 17 cts. per car-mile, and if the railway is crowded with business it is ordered not to move a car for less than $10.91.

It is possible for the reader to compute the freight rate per car-mile on the basis of miles of haul at uniform rates, if interested enough; but this, amounting to a percentage raise, will surely in the present case further reduce the business of the road, and the calculation therefore is not given here.

All of these suggestions are so entirely at variance with the average shipper's or traveler's ideas of equitable rates that, as a matter of policy only, it was deemed wise to vary from them at times and, accepting too little for a short haul, to charge a little too much for a large haul, and by this method of compromises to endeavor to reach a just average in behalf of the railway and realize a profit at the end of the fiscal year, whatever our conviction as to just rates may be.

As in the case of the passenger traffic, it will be necessary at the two points where we touch the steam railways to squarely meet whatever rates they may fix; but for 35 miles between these points we can fix our own rates, and they are honorably fixed, as above described, to correspond with the last-given freight tabulation, for distances ranging from 30 to 100 miles; bills are made out for half the tabulated distances at double the tabulated rates. These are the candidly stated facts.

During the past fiscal year we have:

Freight earnings, gross	$184,942	
Passenger earnings, gross	131,400	
		$316,342
Freight operating expenses	$112,934	
Passenger operating expenses	82,124	
		195,058
Net earnings		$121,284
Taxes	$15,000	
Bond interest $1,000,000 @ 5%	50,000	65,000
Surplus		$56,284
Placed in sinking fund for bonds		50,000

We have not yet felt the item depreciation of $75,000, and will not have to meet it for several years, but must provide for it by increased net earnings. Some further savings in freight expenses can also be made, as our experience of a year has proved some expenses unnecessary. We can hope for increased volume of business from the growth of the district served each year.

GENERAL OBSERVATIONS.

If in other cases the reader rejects the idea of a personal obligation to a railway from residents on its line, he must use the first formula given for uniform rates. It is probable, unless he has practically suffered at the hands of the constituency of a new railway, that his preference will be for uniform rates per mile of haul for both passenger and freight traffic. When, however, one is actually charged with the responsibility of profitably operating a railway and has to meet reckless competition, unreasonable demands, and broken promises, he will be forced to yield to the conditions existing and avail himself of many ingenious expedients for obtaining the business required to render operation profitable. In this case the method adopted in this article may be of value to him in making a scale of passenger and freight charges for a minor railway built as a convenience.

A vast amount of statistical work is being done by the experts of the U. S. Government for our railways, but unfortunately the quantities required to fix railway rates have been omitted in whole or in part in all of it. Bulletin 3 of the U. S. Census, 1902, does not give the individual operating expenses or gross earnings of our electric railways, but gives State averages, regardless of the fact that in the consideration of a given railway, averages derived from the indiscriminate lumping of all the figures of railways in a state are of no value whatever, and are sure to mislead. The Interstate Commerce Commission's reports make no distinction between the cost of (steam) freight train-miles and passenger train-miles, nor do they give the cost of car-miles. Elaborate statements of the revenue per ton-mile and per passenger-mile are given, but no means of closely computing their corresponding costs. Bulletin 21 of the U. S. Census does not give the actual cost of the construction and equipment of our steam railways, which could easily be had from inventories, records or engineering estimates in their absence; but proceeds to calculate the net profits of these railways and from their capitalization deduce the values of the roads.

However useful these results may temporarily be to the investor or stock operator they can not be used by an engineer or railway builder, nor are they of any use in a proper and fair adjustment of railway rates by an impartial referee. What is needed is a knowledge of the true cost of construction and equipment of railways, and that must be followed by the true costs of operation, properly classified. We can then, and then only, fix an honest and profitable railway rate.

Properly directed this great labor and expense (now lost) would have served to fix, at once and definitely, correct railway rates.

The reports on electric and steam railways by State Commissions are often more nearly complete and serviceable, because (more particularly for electric railways) they report individual earnings and expenses, as well as car-miles, passengers

and other data of cost. Massachusetts State Reports are particularly thorough and carefully made; however, even they do not give all the data required for use in our formulas.

What is a fair rate for railways? What is a proper method of apportioning it? To determine these points finally we must have better data than is available now in our statistical reports, and a longer experience than the little railway here discussed has had in its struggles for existence. The figures used in this paper and the formulas written only crystallize out the thoughts and the limited experience of a few men confronted by "a condition and not a theory" in the management of a small local railway.

CONCRETE CONSTRUCTION ON THE CANNINGTON VIADUCT, AXMINSTER & LYME REGIS LIGHT RY., ENGLAND.*

By Arthur Wood-Hill† and Edward Davy Pain.‡

The Axminster & Lyme Regis Light Ry., a single line whose construction was authorized in June, 1899, begins by a junction with the Yeovil and Exeter line of the London & South Western Ry. at Axminster in Devonshire, and runs southward to Lyme Regis, on the coast of Dorsetshire, the total length of the line being 6¾ miles. The country traversed is very hilly, and the route is largely a contour one. The sharpest curves are of 10 chains radius, and the ruling gradient is 1 in 40. The line is laid with 60-lb. flange-rails on transverse sleepers, to the standard gage of 4 ft. 8½ ins.

A careful survey of the various routes by which Lyme Regis could be approached suggested the alternative of three small viaducts in the neighborhood of Uplyme, above Lyme Regis, or one large viaduct at Cannington. The latter was chosen, as being the less costly.

The Cannington Viaduct, which is built entirely of concrete, is situated at 5 miles 21 chains. It consists of ten elliptical arches of 50 ft. span (Fig. 1), the total length of the viaduct being 600 ft., the width over the spandrels 16 ft., and the maximum height to rail-level 92 ft., with a gradient falling 1 in 80 towards Lyme Regis. With the exception of the concrete blocks used as voussoirs in the outer or vertical faces of the arches, the work throughout is in mass concrete.

FOUNDATIONS.—The geological strata at the site of the viaduct consist of greensand and blue lias clay. Boreholes were sunk to an average depth of 20 ft. on the site of the foundations of the piers and the east abutment; but on the site of the west abutment, as the foundation appeared solid and firm and was in strong ground, no boring was done, the bottom being tested with bars only. More trouble was experienced afterwards in this part of the foundations than in any other; but it is doubtful whether boring would have given any indication of such trouble being likely to occur. The foundations were originally designed for a pressure of 3½ tons per sq. ft., but, owing to the soft nature of the ground exposed, it was found necessary to enlarge them, thus reducing the pressure in one case to 1½ tons per sq. ft. The pressures allowed in the various foundations were:

	Tons per sq. ft.		Tons per sq. ft.
West abutment	2¼	Pier No. 6	2¼
Pier No. 1	3	" No. 7	1½
" No. 2	2¼	" No. 8	2
" No. 3	2	" No. 9	2½
" No. 4	2	East abutment	2¼
" No. 5	2¼		

*Abstract of a paper read before the Institution of Civil Engineers, December, 1904.

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As the bore-holes showed that the green sand extended to a considerable depth, the foundations were spread to give the foregoing pressures, and were taken only to such depths as were considered necessary to prevent the adjacent ground from being forced up by the weight of the structure. The greatest depth of any foundation was 10 ft., namely, that of Pier No. 3, where a bed of peat was found.

The concrete consisted of flints, obtained from two cuttings on the line, cleaned, and crushed to pass through a 2-in. ring. It was found that sufficient grit was obtained by the crushing, and that the addition of sand was unnecessary, except for the face-blocks of the arches and for the comparatively thin work in the parapets. The concrete for the piers (including the bottom plinths), abutments, arches, spandrels and parapets was composed of 6 parts of stone to 1 part of Portland cement. In the foundations of the piers and abutments, and in the haunching of the arches, 8-to-1 concrete was used. The cement was spread in sheds, and was turned over and well aerated before being used. It was required to have a specific gravity of 3.1, to withstand a tensile stress of 350 lbs. per sq. in. after 7 days in water, and to leave not more than 4% of residue on a 50-mesh sieve. The tests made during the progress of the work showed an average tensile strength of 563 lbs. per sq. in. The whole of the concrete was hand-mixed, and it was turned over three times dry and twice wet on the stage before being loaded into the skips or barrows.

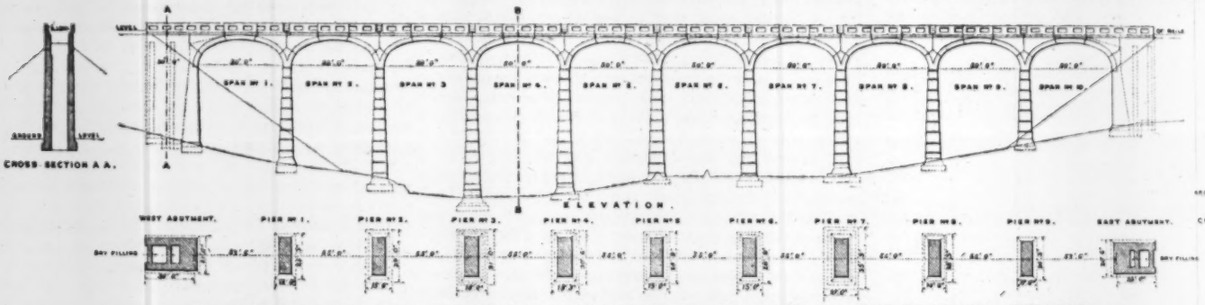


FIG. 1. PLAN AND ELEVATION OF CONCRETE VIADUCT, AXMINSTER & LYME REGIS RY., ENGLAND.

CABLEWAY.—For hoisting and transporting the concrete, the shuttering to the piers and spandrels, and the centering and face-blocks for the arches, a cableway of 1,000 ft. span, with a working-load of 3 tons, was erected across the valley on the center-line of the viaduct. The use of the cableway for hoisting and setting the boxes or molds in which the concrete was deposited in the piers rendered it possible to erect the latter without the aid of scaffolding, thereby effecting an economy of both labor and material.

STONE-CRUSHER.—A stone-crusher was placed at the foot of the embankment, where a sudden drop in the ground provided a fall for a shoot to the mixing-stage. This shoot was pivoted at the upper end, so that the outlet could be moved from one stone banker to another without interruption of the crushing.

PIERS.—The plinth of the piers above the foundations was faced with flint rubble to obviate the use of splayed shuttering. Above the plinth, the piers were built up in rectangular lifts of diminishing size, instead of having a continuous batter. The lifts were 6 ft. in height, the offset between them being 3 ins. at the ends and 1½ ins. at the sides. It was necessary to begin most of the piers with a small lift of less than 6 ft., in order to bring the lines of the chamfers or offsets parallel with the rails and with the springing-line of the arches. The concrete in the piers was deposited in wooden boxes 6 ft. deep, made of 2-in. tongued and grooved boarding with stiffeners 6 ins. by 2 ins., bolted together with ¾-in. tie-bolts (Fig. 2). The boxes were designed so that none of the tie-bolts were built in the finished work. After they had been bolted together on the stage, they were hoisted and set by the cableway, being adjusted to their true position by plumb-lines hung over center-marks cut in the plinths of the piers. The chamfer occurring at each 6-ft. lift—which was made in 2-to-1 cement mortar—was formed in the bottom of the box. The inside of the box was well soft-soaped before the concrete was put in. The concrete was deposited in 2-ft. layers, 36 hours being allowed for setting between each layer. After the first layer had [illegible] deposited, an iron cramp was placed over the [illegible] ide of the box to allow the bottom row of bo[illegible] be taken out. When these had been withdra[illegible] he second layer of concrete was deposited; [illegible] when this had set, the top row of tie-bolts [illegible] aken out and the third layer of concrete w[illegible] t in. As soon as one box had been filled an[illegible] concrete had set, a second box was placed o[illegible] top; but the lower box was not removed unti[illegible] first two layers of concrete had been deposite[illegible] he upper one. By this means the upper box [illegible] given the support of the lower until sufficient [illegible] crete had been deposited to steady the upper [illegible] x and to admit of its being supported by the p[illegible] cting off-set. For the larger or lower lifts [illegible] weight of a box, with its ironwork, was about [illegible] tons. The first boxes were made with vertical b[illegible] ding stiffened horizontally; later, the boxes [illegible] re made with longitudinal boarding, stiffene[illegible] ertically, which gave more rigidity to the sides, [illegible] avoided the fluted appearance given to the fac[illegible] of the concrete by the upright boarding. B[illegible] ies being checked for line by means of a theodol[illegible], the tops of the boxes were frequently levelled at the four corners, any error being adjusted at once. Ordinary box-skips, tipped by detaching the front chains and tilting with the back chains, were used for hoisting the concrete. In the upper portions of the piers, where the boxes became too narrow for these skips to enter, hopper-shaped iron skips were used, having a bottom door held by a catch. The usual rate of deposition was 30 cu. yds. per day, which it was found impossible to exceed in view of the confined space in which the concrete had to be deposited, and of the use of the cableway for handling the shuttering and other materials required for the work. Altogether eleven boxes were constructed, the work in all the piers being advanced at the same rate as far as possible. In the top lift of every pier two rows of corbels were built in to support the arch-centering. These corbels were made in blocks of 6-to-1 concrete and were set by means of the cableway, holes being cut in the sides of the boxes to allow the projecting portions of the blocks to be pushed through. The amount of projection beyond the face of the piers was 8 to 9 ins. The corbels measured 2 ft. 9 ins. × 1 ft. 3 ins. × 2 ft., except the outer corbels of the bottom row, which were made 1 ft. 6 ins. in width in order that the exposed sides might be flush with the ends of the piers.

CENTERING.—The centering (Fig. 3) consisted of four built ribs, placed 5 ft. apart between centers, the middle portion of the ribs being tied by a framework in the form of a Warren girder supported in the middle by raking struts from the lower corbels. The ribs, including the lattice-work, were built complete upon the ground, and were hoisted into position by the cableway. Four tie-bolts were placed in the span to assist the piers in taking the thrust. The two middle tie-rods were of 1¼-in. round iron, with link-couplings; the two outer ties were made from rails weighing 18 lbs. per yard. When depositing the last layer of concrete in the piers, holes were formed for the inner rods by building in a wooden rod, which was drawn before the concrete had set hard. The outer rods passed through the sills, close against the ends of the piers, but did not pass through the concrete.

ARCHES.—The faces of the arches were built of concrete blocks, which had been allowed to harden for 2 months before being placed in position. The blocks are 2 ft. 6 ins. in depth by 1 ft. 7 ins. in width on the soffit, and are alternately 3 ft. 6 ins. and 2 ft. 6 ins. in length, forming a toothing on

the inside for the mass concrete. With the exception of the middle ten blocks, which are of the same section, every pair of blocks was cast in a separate mold, to suit the curve of the arch. The two similar blocks on the right and left sides of the viaduct were set simultaneously by attaching them in equipoise to the two ends of a piece of flanged rail slung from the hoisting rope of the cableway, and were lowered steadily into position (Fig. 4). When molding the blocks, two holes were left in each for the lifting-irons. By varying the lengths of the chains attaching these irons to the ends of the rail, the blocks could be suspended at the angle required by their position on the curve of the arch. This arrangement considerably reduced the labor of handling the blocks, and the two faces of an arch could be set in 2½ days. The weights of the large and small blocks were 17 cwt. and 13 cwt. respectively, which were found convenient in adjustment on the centering. The blocks were jointed in 2-to-1 cement mortar, and were keyed in advance of the mass concrete, in order that the adhesion of the latter to the toothing of the blocks might relieve the centering of some of the weight. Expansion-joints in weak lime mortar were formed between the blocks and in the mass concrete, at the positions indicated in Fig. 1. In bringing round the mass concrete, care was taken to form a radiating joint whenever the work was left off. The haunching was completed up to the level of the drainage-grids before the mass concrete between the two expansion-joints on either side of the crown was keyed in. The building of the arches was commenced in span No. 10, i. e., at the low end of the gradient, and was continued regularly up to span No. 1. Four sets of centering were used, the time allowed for the setting of an arch before striking its centering being 3 weeks. In turning the arches, the depression of the centering at the crown was about 2½ ins. In spite of its apparent lightness, the centering was found to be sufficiently rigid in all respects, and the setting was greatly facilitated by the ribs being made in one piece. Three-inch cast-iron drain-pipes were built through the arches, a sump being formed in the center of the haunching. The arches were coated with a layer of asphalt, ⅝-in. in thickness, and the inner face of the spandrels was rendered in cement to the top of the dry filling. The parapets are 18 ins. in thickness and 4 ft. 6 ins. in height above rail-level, and in order to obtain a clear width of 14 ft., each parapet oversails 6 ins. from the face of the viaduct. Panels were formed in the outer face, for the sake of appearance, and to reduce the weight of the walls. Refuges are formed over the center of each pier by a break in the walls, three galvanized-iron bars, 2½ ins. × ½-in., with bent ends, being built in to form a protection flush with the outer face of the wall. The expansion-joints of the arches and spandrels were continued vertically through the parapets with a V-joint, their positions being made to correspond with the ends of the panels. The expansion-joints, extending, as they do, from the soffit of the arch to the top of the parapet-wall, were found very effective in providing for all expansion or contraction of the concrete, and for any movement due to settlement of the piers; in fact, except in span No. 1, which was affected by a subsidence of the embankment and west abutment, to be described later, no cracks appeared in the work. The maximum opening of any expansion-joint was ½-in.; the majority showed only slight enlargement.

SETTLEMENT OF PIERS.—Levels were taken at the ends of the piers to ascertain their settlement. The majority of the piers settled 4 to 6 ins., the movement becoming slight towards the completion of the work. These settlements, being fairly even and adjusted as the work proceeded, were not found to affect the concrete; but at the west end of the viaduct the movement was more serious, and trouble arose from subsidence in the case of the west abutment and pier No. 1. Owing to continual heavy rains in the spring of 1903, a slip took place in the west embankment, and further settlement of the abutment and pier No. 1 occurred between March and May of that year. The effect of this subsidence was to crack the crown of arch No. 1, and contractors' traffic over the viaduct had to be suspended. The centering was immediately replaced in spans Nos. 2 and 3, that in span No. 1 not having been removed. Raking struts were fixed temporarily from the embankment to the soffit of arch No. 1, a few feet above the top of pier No. 1, in order to give support to arch No. 2. It was decided as a first step to build two diaphragm-walls in span No. 3, to enable it to act as an abutment, if required. Details of these walls are shown in Fig. 5. A concrete foundation, stepped at the bottom to suit the difference in level of the piers, was laid in sections between piers Nos. 2 and 3, the upper surface being brought to an even slope. The first section of concrete abutting against pier No. 3 was carried down to the same level as the pier-foundation, but owing to the tendency, when excavating near the bottom of the pier, to draw water and soil from beneath it, the remainder of the concrete was not carried lower than the top of the 3-ft. slab forming the base of the pier. Against pier No. 2, where the foundation was dry, the concrete was carried to the same depth as the foundation of the pier. The average thickness of the stepped portion of the concrete was 5 ft. 9 ins. The diaphragm-walls were 3 ft. 9 ins. in thickness and 6 ft. 6 ins. apart, and were lightened by two openings, with relieving-arches of 30 ft. span. The walls were built entirely of brickwork in cement, in which material they could be constructed more expeditiously than in concrete. Light buff stoneware bricks made at Torrington, almost equal in hardness to Staffordshire brindle-bricks, were used in the facework, and made a fair match with the concrete in respect of color. Ordinary hard red bricks were used in the inside work. The walls were tied together by 45-lb. flange-rails with bent and flattened ends built into the brickwork, four rails being placed at every 10 ft. in the height of the walls, and additional rails being built in to tie the arches. For constructing the walls a scaffold was slung from the ends of two heavy balks secured across the top of the parapet-walls. A light steam-crane, working over span No. 3, was used for lowering materials on to the scaffold. As soon as the concrete foundations in span No. 3 had been completed, two concrete needles or struts 4 ft. by 3 ft. in cross section, were built in the embankment, between piers Nos. 1 and 2, as a support to pier No. 1 against the pressure of the embankment (Fig. 6). Immediately before the completion of the diaphragm-walls, the cracked portion of arch No. 1 was dealt with. The crown of the arch was cut out between the expansion-joints, i. e., for a length of 18 ft., in widths of 4 ft., and was made good in brickwork in cement, the buff stoneware bricks being used throughout. Timber struts were fixed above the arch, for safety, between the expansion-joints of the spandrels, while the damaged part of the arch was being renewed. The faces of the arch, where renewed in brickwork, were rendered in cement to match the concrete. In order to reduce the weight upon the crown, the rails and sleepers were laid upon four 54-ft. timbers, 16 to 18 ins. square. The building of the parapet-walls over arch No. 1, and the removal of the centering from spans Nos. 1 and 2, completed the work.

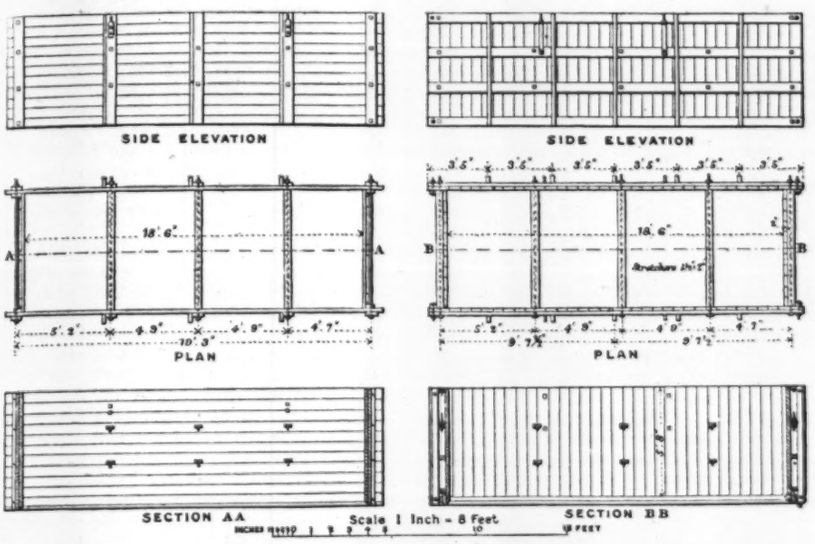


FIG. 2. BOX FORMS FOR CONCRETE PIERS.

COST.—The total cost of the viaduct, exclusive of the additional work entailed by the subsidence described, was £10,820, including all labor and materials, establishment-charges, and use of plant. Of this sum the concrete cost £10,314, equivalent to an average of £1 12s. 1d. per cu. yd.

The chief quantities were:

Excavation in foundation	953	cu. yds.
8-to-1 cement concrete in foundations and in backing to arches	1,126	" "
6-to-1 cement concrete in piers, abutments, arches, spandrels and parapets	5,303	" "
Dry-stone filling in pockets of abutments and over arches	1,330	" "
Cement rendering to spandrels	372	sq. yds.
Asphalt	747	" "

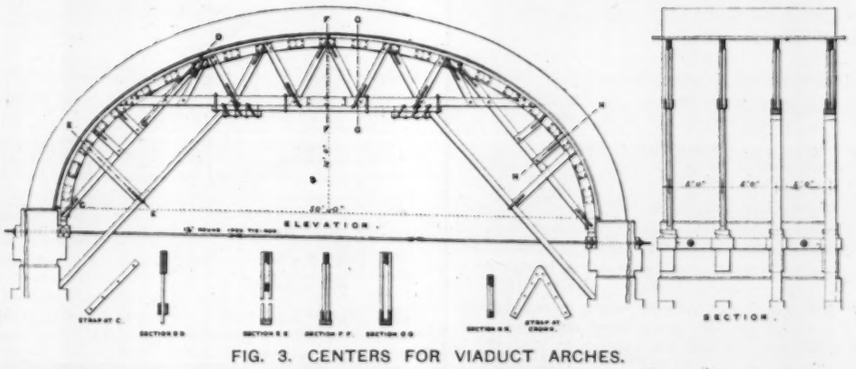


FIG. 3. CENTERS FOR VIADUCT ARCHES.

The viaduct was commenced on Sept. 19, 1900, and the contractors' trains were run over it on Oct. 21, 1902, the work being then finished, with the exception of the parapet-walls. The cableway was in use from May, 1901, to February, 1903. The extra work entailed by the subsidence of the west abutment postponed the opening for public traffic until Aug. 24, 1903.

The Engineer was Mr. Arthur C. Pain, M. Inst. C. E., his son, Mr. Claude Pain, Stud. Inst. C. E.,

acting as Resident Engineer. Messrs. Baldry & Yerburgh, of Westminster, were the contractors. Of the authors, Mr. A. Wood-Hill had charge of the work for the contractors, and Mr. Edward Pain assisted his brother. The authors are in-

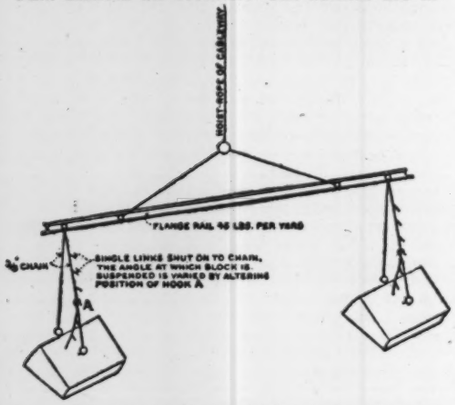

SWIVEL HOOK OF CRANE
FLANGE RAIL 45 LBS. PER YARD
SINGLE LINKS SHUT ON TO CHAIN. THE ANGLE AT WHICH BLOCK IS SUSPENDED IS VARIED BY ALTERING POSITION OF HOOK A
A

Fig. 4. Device for Handling Two Voussoir Blocks Simultaneously.

debted to Mr. Arthur C. Pain, Mr. H. O. Baldry, M. Inst. C. E., and Mr. Claude Pain for assistance in the preparation of this paper.

THE MANUFACTURE OF CONCRETE BLOCKS AND THEIR USE IN BUILDING CONSTRUCTION.

(Extracts from Papers Submitted in Engineering News Competition, and Not Receiving Prizes.)

II.

Besides the two papers awarded prizes in Engineering News Competition, there were received ten others, nearly all of which contained contributions of value to the knowledge of the subject of concrete block manufacture and use. From these ten papers we have selected extracts, and arranged them under descriptive headings for publication. The method of presentation adopted as most nearly fair to all is to give the author's name in each case, and follow it with the extract selected in as nearly as possible the author's own words. When two or more authors have presented the same fact, that author's presentation which seemed to us best, judged by the rules under which the competition was held, has been chosen.

The names and addresses of the authors from whose papers extracts have been taken are as follows: Joseph Babiczky, Guardian Trust Building, Kansas City, Mo.; Geo. H. Crafts, Box 245, Atlanta, Ga.; H. H. Frantz, 3621 West Grand Ave., Des Moines, Ia.; U. G. Hayne, Fort Stevens, Ore.; Noyes F. Palmer, 150 Snediker Ave., Brooklyn, N. Y.; H. H. Rice, 381 South Logan Ave., Denver, Colo.; H. G. Richey, Superintendent, U. S. Public Buildings, Evanston, Wyo.; G. W. Robertson, 105 Walnut St., Marion, O., and G. W. Stevens, 15 Warrenton St., Boston, Mass.

The subjects considered in this article and the remarks under each are as follows:

Proportioning of Mixture.

The proper proportioning of the various ingredients is a question upon which the several writers exhibit great divergence of opinion.

Joseph Babiczky.—My experience is that 1 part cement and 5 parts sand properly mixed, tamped, handled and cured gives blocks as good as any common building stone. If suitable crushed stone can be obtained, a combination of 1 part cement, 3½ parts sand and 6 parts stone makes a good mixture supposing that the sand is not too coarse and the stone varies in size from ½ in. to dust.

G. W. Stevens.—For the wet process the following proportions can be used: 1 part cement, 1 part fine sand, 2 parts coarse sand, 2 parts fine gravel and 2 parts coarse gravel. For the dry process the following mixtures are suitable: (1) For facing, 1 part fine sand, 1 part coarse sand and 1 part cement; for backing, 1 part fine sand, 2 parts coarse sand, 3 parts fine gravel and 1 part cement. (2) For one mixture throughout, ½ part fine sand, 3½ parts coarse sand and 1 part cement. (3) Same face mixture as above; for backing, ½ part fine sand, 2½ parts coarse sand, 2 parts fine gravel and 1 part cement. (4) 1 part fine sand, 2 parts coarse sand, 3 parts coarse gravel and 1 part cement.

Noyes F. Palmer.—In regard to cement and its aggregates, it matters not if it be a mortar block of 1 cement and 4 sand, or a concrete block of 1-2-4 or 1-3-5 composition. The practical thing is to find out how to fill the voids in all cases so as to get the greatest strength in the cured block.

U. G. Hayne—In most cases a mixture of 1 part cement to 4 parts sand should be used for blocks. This proportion can be used where blocks are to be put to the severest test as to fire, compression, tension, etc. I would recommend a facing of about ¾ in. in thickness of 1 part cement and 2 parts sand mixed a trifle drier than the body of the block. This will permit the face mold to part freely from the mortar leaving a clean cut face.

H. H. Frantz.—Use mixture of 1 cement, 2½ sand and 3½ broken stone proportioned by measure.

G. W. Robertson.—To determine practically the amount of cement needed for making a good block have found a simple and satisfactory way to be to get two graduates such as druggists or photographers use, one of say 24 oz. and the other of 8 oz.; fill the larger with the coarse aggregate and then from the smaller pour in water until it stands on top of the material; note amount of water used; empty large graduate and fill with same material, to which add the amount of fine material (sand or stone dust) indicated by the amount of water noted; mix the fine and coarse material thoroughly, then add water from smaller graduate as before; the amount of water used will give amount of cement needed to make good blocks.

Consistency of Mixture.

In respect to consistency, practice classifies concrete mixtures for block manufacture into wet mixtures and dry mixtures. Concrete block machines are designed specifically to use one or the other of these mixtures.

H. G. Richey.—It is the opinion of the writer that the use of such a number of molds as will permit the mixture to be left in the mold about 12 hours will result in the production of the better blocks. The concrete can then be mixed with

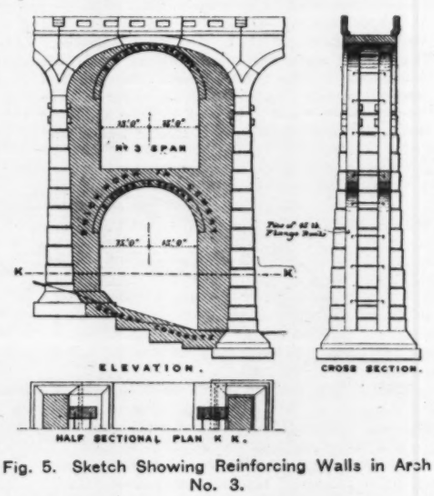


Fig. 5. Sketch Showing Reinforcing Walls in Arch No. 3.

enough water to permit solid tamping and to provide for the proper crystallization of the cement; this will make a much harder and more dense block than many of the dry mixtures now in use. In making a block where the mold has to be removed immediately the concrete must be dry enough to stand up when the mold is taken away, and the block must stand from 6 to 8 hours before it is safe to wet or sprinkle it without fear of destroying the face or arrises. Concrete made as dry as this and then exposed to the air while the setting of the cement is taking place [illegible] sufficient water to cause complete and crystallization. The writer does not adv[illegible] mixture so wet that it can be poured [illegible] molds, but the mortar portion of the [illegible] should be of about the same consistency [illegible] tar used for laying brick or stone.

Geo. H. Crafts.—About 10% by weight o[illegible] is the proper proportion to use for the [illegible] for tamping and pressure processes, but [illegible] double this amount is necessary for the p[illegible] process.

U. G. Hayne.—While the reason in favor [illegible] ploying the make of machine that uses we[illegible] ing concrete and permits it to set in the [illegible] is a good one, it is more than balanced b[illegible] large number of molds required for work. W[illegible] reinforcing prevents thorough tamping, or [illegible] the surplus water can be quickly drawn off, [illegible] the only cases in which I would sanction a[illegible] cess of water in this class of construction. W[illegible] well tamped in the mold there should be [illegible] enough water in the concrete to show on the [illegible] tamper.

H. H. Frantz.—The mixture must be made sufficiently liquid that the mere shaking of the mold will settle the mass; a stone thus made will be found far better and much more impervious to water than one made by the dry process.

Joseph Babiczky.—For tamping and pressing the materials must be mixed with only so much water that the mixture is of the consistency of damp garden earth. For the pouring process the mixture must be so wet that it runs easily out of the buckets.

G. W. Stevens.—I am in favor of wet concrete. The concrete should be made wet enough to flow freely under the cores and into the corners.

Noyes F. Palmer.—The less water used in the process of molding mortar or cement blocks the less voids and a resultant greater strength.

Methods of Mixing.

Two methods of mixing the ingredients, first machine mixing and second hand mixing, are available in concrete block manufacture as in general concrete work.

G. W. Stevens.—A wooden floor should not be used; a cement or earth floor with a coating of fine sand spread over it is a desirable one. In summer, especially, have the mixing floor so that the sun does not shine on it, and where there is no draft of air.

Joseph Babiczky.—The ingredients must first

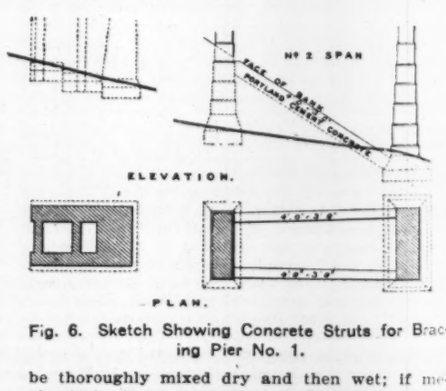


Fig. 6. Sketch Showing Concrete Struts for Bracing Pier No. 1.

be thoroughly mixed dry and then wet; if mechanical mixing is employed the mixer should provide for separate dry and wet mixing; it should also provide for the addition of the water in a fine spray.

H. H. Frantz.—Provide yourself with a mixing box on wheels; box should be say 6 ins. deep, 3 ft. wide and 5 ft. long. Place in the box 2½ parts by measure of sand well scattered, spread over this 1 part of cement and mix thoroughly with hoe, shovel or rake. Next add clean water and beat up to consistency of soft mushy mortar. Finally add 3½ parts of gravel and mix and beat to a soft mixture.

H. G. Richey.—When the plant is large enough to justify the expense a power mixer will be the most economical as well as the most convenient. For a block plant a batch mirror will prove the

best, for by it the concrete can be mixed as thoroughly as desired. In any machine mixing the cement, sand and aggregate should first be mixed thoroughly while dry, then the water should be added in just sufficient quantity to make a soft plastic mixture, which will tamp readily in the molds, and after being tamped lightly will quiver at each stroke of the tamper. When the mixing is done by hand with shovels or hoes, the cement and sand should be mixed dry, then with water to make a mortar of the consistency described. Finally the aggregate previously wetted should be added and thoroughly and evenly incorporated with the mortar.

Geo. H. Crafts.—Undoubtedly machine mixing is much better than mixing by hand as it is much more thorough. A batch mixer mixes thoroughly all the ingredients of a batch, and can be kept running continuously if the material is not wanted just at the time it was mixed, whereas a continuous mixer has to be stopped, since it will not continue to mix the same material. It is better to mix the materials in a dry state at first and then gradually add the water in a spray and continue the mixing. The longer the mixing is kept up the better as experiments show that the strength of concrete is increased by mixing even up to two hours after being wetted.

U. G. Hayne.—Hand mixed concrete should be mixed on a tight platform, or in a large mortar box, with square pointed shovels or mortar hoes. Measure and spread the sand evenly over one side of the platform, or in one end of the mortar box, care being taken to have it spread evenly and 8 ins. to 1 ft. in thickness. On top of this spread the required quantity of cement, taking care to have the cement well distributed on the edges of the layer of sand. On each side of the platform place a man with a square pointed shovel prepared to shovel the concrete to the vacant side of the platform. The shovel should be run along the edge of the pile, filling from what rolls down and when full should be turned to a separate pile with a spreading motion, care being taken to have all the pile thoroughly turned as there is a tendency at first to slight the portion where the two shovels meet. The object of the shovelers should be to have gravity aid in the mixing as much as possible by handling the concrete so that it rolls down on the pile, being shoveled from as well as on the one shoveled to.

Two or three good turnings should give the concrete an even color; if not, it should be turned until it is of one. Then the concrete should be evenly spread out and the water added, preferably with a sprinkler, though I have seen no evil effects from taking the quantity of water required and gently pouring it on top of the pile, and after letting it stand for two or three minutes mixing in the same manner with the shovels as before, adding the water. The turning should be continued until the water is thoroughly incorporated in the concrete, and, when finished ready for the molds, a quantity of the concrete tightly squeezed in the palm of the hand and the hand opened palm up, should remain like a ball on the hand.

Using the mortar box and the hoes, the sand and cement should be spread in one end of the box evenly, the same as described for the platform. The man mixing then stations himself at the opposite end, and hoes the concrete toward him with a quick downward stroke, pulling quickly toward him at the same time the stroke ends, and taking a cut of about an inch into the concrete each time. This quickly and thoroughly mixes the concrete. Turn the whole quantity back the same way to the end it was first in, or two turnings, add the water and turn until the mixture is all of the same wetness.

There is no question but that machine mixed concrete, where the machine is correctly used, is better and more thoroughly and cheaply mixed, than by hand, and as soon as the business will justify it one should be used. Would not attempt to use a hand-power mixer but a gravity or power one. The danger to be avoided above all, though, is to not mix too much concrete at once, as the temptation is too great to use it, if mixed, even though the initial set has begun. With some cements, concrete used within 1½ hours is all right, but with most 20 to 30 minutes is about the limit.

Block Machines and Molding.

Concrete block machines are designed to use either a wet, a machine or a dry mixture, and the construction of the machine and the process of molding vary for each mixture.

H. H. Rice.—The most simple form of mold ever devised for making a hollow concrete block consists of two side boards with cleats to engage end boards, clamps to keep the sides in position, two or three pieces of stove pipe to form the hollow spaces, with a piece of 2 × 4-in. timber for a tamper, the latter shaved at one end to fit the hand. If you have some knowledge of cement and a little mechanical skill, it is possible for you to make very good blocks with this outfit. If you do not understand the action of cement, and have no mechanical skill, it is possible for you to make very poor blocks with the latest improved appliances. And I may here say that the genius of the inventor and the mechanic is exemplified in varying degrees from the mold I have described to the most modern machinery in block manufacture, while the energy, perseverance and ability of the operator are displayed in varying degrees from blocks whose quality has irreparably injured the standing and reputation of artificial stone to beautiful, lasting and symmetrical edifices, which are things of beauty and a joy forever. Don't forget that the best machine requires mechanical commonsense to obtain the best results.

I have said that all processes are roughly classified as tamped, poured or pressed, and again, in the same order, as dry, wet or medium. I shall first consider the machines for making blocks by the comparatively dry hand tamped process. These machines consist, in general, of a stand to bring the bed to convenient working height surmounted by a mold containing interior cores. The mold is filled with a moist mixture of sand and cement, tamped well as the mold is filling and slightly heaped up at the last to permit leveling off with a straight edge. Now there are very many different machines of this type in market to-day, and their chief differences may be summarized as follows: Some drop the interior cores mechanically from the block, then unclamp and drop the sides, thus leaving the block free on the bottom plate ready to be carried to the curing yard. In others, the cores and the frame surrounding the mold are stationary while the bed moves upward to release the block and the same upward motion disengages the sides from the surrounding frame, allowing them to fall away from the block; when the bed is lowered the cores come into proper position and the outer frame engages the hinged sides and ends so that one downward motion throws the entire mold into position for refilling. In others the sides are hinged on a corner, the bed stationary and the cores movable, so that in releasing one side and one end are laterally withdrawn from the block and the cores dropped out of the block, as in the kind first described. Still others have longitudinal cores which are withdrawn by hand. Certain of these machines have a device for throwing the mold at 45° angle to permit of applying face matter as already mentioned. Another type of machine, though following the same general lines of construction, has the mold turned on the side to more easily face the blocks, and the latter type withdraws the interior cores laterally. The above fairly covers that general type of machines in which blocks with interior cores are manufactured by tamping. You will note that but slight structural differences obtain, the diversity being more in the line of labor-saving devices. All contemplate the use of hand or automatic tampers, and hence neither wet nor medium mixture may be used. If this is attempted, the mass will squash under the blows of the tamper, while if comparatively dry it will pack to an extent sufficient to enable the block retain its shape while being carried (on the bottom plate) to the curing yard. Subsequent sprinkling is relied upon to secure additional crystallization. The best practice does not admit of placing such blocks in the wall under twenty days. While some manufacturers claim that coarse material, either gravel or broken stone, may be advantageously used under this process it has never been my good fortune to see this practice followed in commercial manufacture, and I believe sand and cement to be best adapted for use in the machines already mentioned.

Next in order we have the wet or poured process, which is characterized by sheet iron molds in which a fluid mixture is poured. Either fine or coarse aggregates may be used with equal facility. The paramount ideas of this process are that a copious admixture of water causes the cement in fluid state to thoroughly permeate the aggregate and completely coat every particle thereof, and that such immediate and plentiful application of water secures a thorough crystallization in the initial set. There can be no question about a block so produced being both strong and durable, though there is some doubt as to the uniformity of that strength on account of the gravitation of heavier particles to the bottom of the mold. By the use of porous molds one manufacturer aims to avoid the porosity in the block due to an excessive amount of water creating voids by subsequent evaporation. The chief objection, however, to this process appears to lie in the fact that the block must remain several hours in the mold before attaining sufficient firmness to retain its form. Hence, an unreasonably large number of molds is required to produce a reasonably large output.

We have yet to consider the medium or pressed process, in which from seven to eight per cent. of water is used, and a considerable proportion of gravel or broken stone. As this process is comparatively new the systems based on its principles are less numerous than those under the processes previously considered, but I have found a considerable number of factories turning out a satisfactory product. As the pressure is simultaneously applied to every portion of the block, the difficulty mentioned in using a wet or medium mixture under tamping is obviated. On the one hand, this process eliminates the time consumed in tamping under the dry process; on the other hand, it eliminates the time consumed in setting in the molds under the poured process. It may fairly be said to partake of the nature of both, inasmuch as the amount of water in the mixture is sufficient to flush to the surface under pressure, and the blocks are afterward kept thoroughly saturated with water for a week before going into the wall—thus securing both the initial set and subsequent crystallization. The application of pressure necessarily eliminates the use of interior cores, and hence blocks are made in the "T," "E," "U," or "L" shapes mentioned in a previous paragraph, the molds providing for adjustment to all widths of wall by shortening or lengthening the arms of the blocks. The best results under this process appear to be obtained by pressing the block with the face up, for two reasons: First, the pressure applied in this way insures a hard, dense and comparatively impervious face; second, it affords an opportunity to first shovel the coarse concrete into the mold, and lastly (before pressure) to apply the rich face matter, which, under a heavy pressure, becomes well bonded with the body of the block.

Geo. H. Crafts.—There are three general systems of filling and compacting the mixture into the forms desired: the pouring, tamping and pressure systems. In the pouring system, the concrete material in a wet condition is poured into the box or mold, great care being taken that the mold is completely filled in all parts, and particularly in the angles and corners, and that no air holes are in the material. The one-piece block is the block generally used in the pouring system of work. In the tamping system, which is the one most in use at the present time, the material in a damp condition is thoroughly tamped by hand tampers as it is put into the box, and especial care has to be taken that the edges and the corners are thoroughly rammed. The one piece block in multitudinous forms is the one generally used in this system. In the pressure system the material, which is in a damp condition, is pressed by hydraulic pressure, or pres-

sure secured by toggle joints or other mechanism, into the box. Hydraulic pressure gives the heaviest or most exact pressure as the amount of pressure is shown exactly by a gage attached to the machine, and is the same regardless of the amount of material in the box. With the toggle joint machines, the pressure is more or less indeterminate, depending on the amount of material put into the box. The two-piece block is the one generally used in the pressure system, although the one-piece block can be made.

G. W. Robertson.—Too much care can hardly be given to the selection of a block machine, as upon the machine largely depends failure or success in block making. Aside from the fact that a majority of those engaging in the manufacture of blocks do not have the necessary capital to purchase and outfit a plant with hydraulic machinery, I do not believe the results obtained from the use of such an outfit justify the outlay either as to amount or quality of blocks made. Taking into consideration the fact that the pressure applied is for but a fraction of a minute, and that to a material in what might be called practically an air tight box or mold, and I believe the result will be found to be a block with two surfaces more or less compact, while the main body of the block is filled with air channels, where the air has been suddenly expelled or compressed, giving a block that will readily absorb moisture. Select a machine that will give varieties of the most salable size blocks. Get a machine with as few cogs, gears, springs and levers as possible, for you will find all such not only limit the life of the machine, but are liable at any time to get out of order from clogging with concrete. Do not get a machine standing too high, as then you will either have to build a platform for workmen to stand on or they will be working at a most decided disadvantage. Prefer also a machine using removable cores, as not only are they less liable to catch or stick when coarse material is used for backing, but are also more quickly handled than machines with fixed cores. Prefer again a machine in which blocks are made face down and after being made are revolved, say, one-fourth to rest on pallet when machine is opened. Face, side and end plates should be accurately machined so they may fit properly, and not used just as they come from the mold, else you will always have trouble in getting your plates to fit, and also in having your blocks correct in size and shape. As to pallets for use with machines prefer wooden to iron, because of lower first cost and cost of maintenance. With common care wooden pallets will last nearly as long as iron, and their first cost should not be over one-sixth that of iron pullets.

Noyes F. Palmer.—Concrete blocks cannot be too good, and hence the heavier the machine and the more automatic its action and positive its movement, the cheaper the product. A machine must have adjustability to permit the manufacture of varied shapes. It must be the most favorable in functions to permit open top tamping and, like the flask and drag in the foundry, easily got at and handily manipulated.

G. W. Stevens.—A good way to judge a block machine is to find out how long it takes to set up and take apart the machine in actual work. Some of the points to be considered are these: Is it complicated and likely to get out of repair quickly? Are the castings light and easily broken? In the wet process the concrete should be wet enough to flow freely under the core and into the corners. By raising the end of the mold and letting it drop suddenly the concrete will be sufficiently settled. In the dry process fill in 2 or 3 ins. of concrete, give the first blows to the corners and the edges, and, finally, tamp the body. As soon as hard stop tamping. If tamped too much the layer will be smooth and be liable to cause a seam; the surface should be left a little rough so that the next filling will adhere to it. The last filling should bring the material above the mold so that it can be tamped solid and struck off with a straight edge.

H. H. Frantz.—The first things needful are "molds" or "forms," of which hundreds of patented articles are now on the market, but fortunately these need not be expensive, nor patented, nor is machinery at all necessary or essential; what is needed is a simple steel mold or form. This will consist of only four pieces of steel plate, say ⅛-in. thick, two sides and two ends, with the edges stiffened by riveting thereto steel angles, and arranging the angle joints so that these can easily be connected, and disconnected and firmly clamped; the inner surface should be perfectly smoothed. The size will of course depend on the size of block that may be desired; a block 10 ins. thick × 10 ins. high × 27 in. long would be fair. Of these molds a number must be provided, and with each there must be a smooth wood bed plate, say 12 × 30 ins. long, having a true smooth surface. The next requisite is a "core" (that is, a form of wood or metal) to be laid inside the mold, to form the hollow space in the block. It may be of any desired form. The block may have one or more hollows, extending through the block, from side to side, but their size should be such as will leave the walls or shell of the finished block of sufficient strength, from 1½ ins. to 2½ ins. thick, and their shape must be such that, after the cement block has been formed, it can easily be withdrawn, without disturbing the material of the block, usually in two parts, half to draw out from either side.

U. G. Hayne.—I can see no special object in making a concrete brick the same size as an ordinary clay building brick, except that of force of habit. I will not, therefore, consider that form of block more than to say that it can be made and laid the same as ordinary brick, but there is no saving in cost of laying in the wall over that of laying brick, which is quite an item in using concrete blocks. It may be that in some localities the call for blocks the size of brick will be such that a machine for making them will be a valuable addition to the plant. Then there is the choice between the machine in which the concrete is permitted to set in the mold, having the concrete wet enough to pour, and the one that uses the concrete of such wetness that the molds can be stripped from the block immediately, and the process of filling repeated.

While the point in favor of employing the make of machine that uses wet flowing concrete and permits it to set in the mold is a good one, it is more than balanced by being compelled to have so many molds to do the work with. Just as good results can be obtained with the machine using material of such wetness that it will stand to have the molds removed immediately.

Where reinforcing prevents the use of good tamping, or where the surplus water can be quickly drawn off, are the only cases in which I would sanction an excess of water in this class of construction. The simplest made machine with the least gearing and parts to get out of order will give the best satisfaction. On account of the danger of jarring the block, while handling it, after taking it from the machine to the place where it is to be cured, I would favor the machine that is taken from the block, after the block is in place for curing. The strength of the concrete can be much weakened and the block still hold its form, or the stone may be checked and the harm not noticed at the time, and thus result in making a poor block.

Machine or power tamping in a large plant should be all right, though, as I understand the situation, the power tamping machines are not all the success that they should be. A pneumatic tamper handled by hand in a similar manner as the pneumatic riveter is said to be giving good satisfaction. On account of the expansive quality of air, the pressure made block is somewhat weakened by the expansion of the air in the stone when the mold is taken from it. I know of no machine of the pressure type that is a good block maker and believe this to be the reason.

This brings the question of the machine down to the one that can be easily carried, and to hand, or pneumatic, tamping. Add to this the ones that the makers are willing to furnish a copy of any patents they may have, and the makers' ability to prove that they will protect the purchaser in his rights, and the machine deal is ready to close. A machine with a patent on it is not of as much consequence as the features of the block and air spaces that are pate[illegible] In a wet country the double, staggered air s[illegible] are more apt to make a warm, dry wall.

As to the speed of operation [illegible] machine, there are few if any machi[illegible] but that will make as many blocks as m[illegible] can be tamped into them and taken out. [illegible]essed in other words: they are limited only [illegible]he skill, dexterity and handiness of the c[illegible] handling them, and a gang of three men sho[illegible]e able to make from one hundred and twen[illegible]e to one hundred and fifty blocks, of an av[illegible]e size of 8 ins. high by 9 ins. wide, by 2 ft. l[illegible] in a day of ten hours.

A machine guaranteed by a good, [illegible]ble company should be considered above one [illegible] so warranted, other things being equal. [illegible]ugh the cost of compelling the making good [illegible] the guarantee makes it of uncertain value. The only feature of exclusive rights that has an [illegible]real merit is the one where the patent applies t[illegible]me good feature of the structure of the block [illegible]d not to the machine. There are so many [illegible]chines of practically the same price and capacity that the exclusive right to use a certain machi[illegible] without a block patent would be of little if any [illegible]alue.

H. G. Richey—After deciding on the location of the plant, then will come the selection of machines or molds. This is a matter that must be left to the party who is to operate the plant; for different people prefer different machines or molds. He should visit the different plants in operation and see the various machines at work, and then after making all the inquiry he can about them select the one that most favorably impresses him.

There are quite a number of machines on the market at the present time, and all are turning out about the same quality of block. So far as quality is concerned, it is not so much the machine or molds as the materials used, the proportions in which they are mixed, and the manner of using them, that determines the quality of the block. A person in selecting a machine should select one which is not too complicated, and which is as simple as possible in its operation.

Some manufacturers of machines, in addition to selling their machine or molds, are selling exclusive territory for the use of the machine. The writer considers money paid for the right to use any particular machine in a certain territory is money thrown away, for there are so many different makes of machines on the market that the buying territory for the use of any particular machine will not give the purchaser the exclusive right to manufacture concrete building blocks in that territory. Some other party with a different make of machine will step in, and turn out blocks equal to the ones made by the person who paid his money for exclusive territory. Thus the writer would be adverse to paying money for territory, but would take the money thus saved and purchase additional molds for making a larger variety of blocks.

The location and amount of business contemplated will also have to be considered when purchasing a machine. If it is not expected to do a large business a set of ordinary molds may be sufficient, but in another locality where there will be a large demand for the blocks a larger number of molds or machines will be required.

PROTECTING RAILWAY WATER TANKS FROM FREEZING.

A committee report on the subject of frost-proofing of railway water tanks, made to the Association of Railway Superintendents of Bridges and Buildings, at its recent Pittsburg convention, gives information concerning the available means of protection against freezing, and the extent to which the several means are employed. The report does not relate how much trouble is experienced on the principal northern railway lines from the freezing of wayside tanks, but some testimony on this matter appeared in the oral discussion at the convention.

The discussion leads to the conclusion that very much annoyance, and delay occurs from this source on some railways, while on other railways little or no trouble is had, and water tanks never

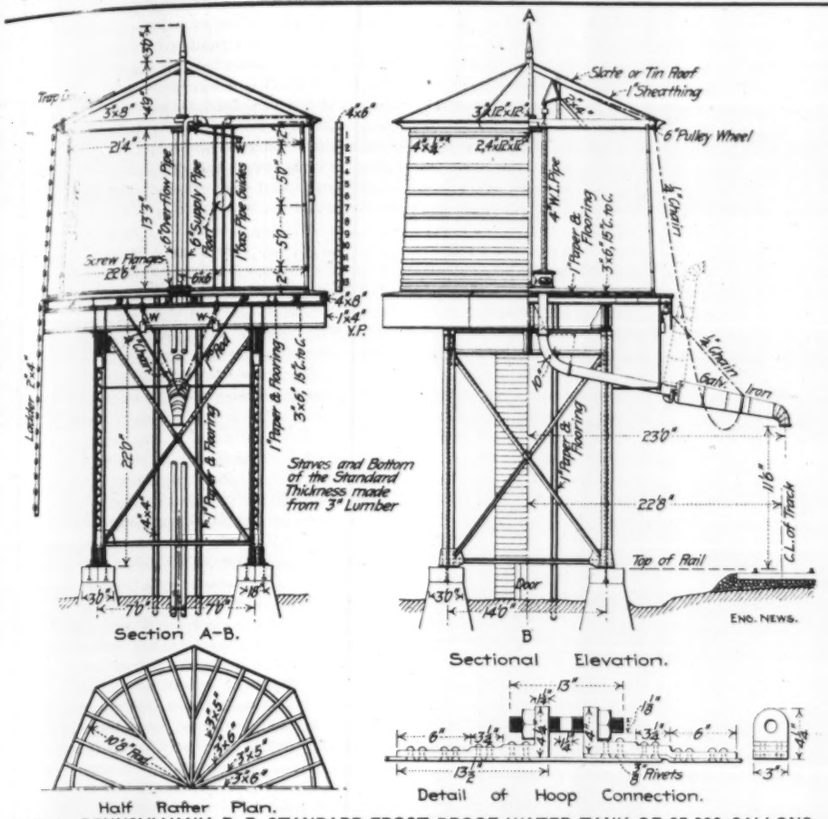


FIG. 1. PENNSYLVANIA R. R. STANDARD FROST-PROOF WATER TANK OF 35,000 GALLONS CAPACITY.

freeze up. Two railways whose experiences are thus opposite may be located approximately in the same climatic belt, so that winter temperatures, winds, etc., are not the sole conditions at the bottom of the problem. The size of tank, which would affect the rapidity of freezing, is not so greatly variable as are factors such as rate of draft from the tank, nature of supply water, and degree of care regularly given to the tank in autumn and winter. The last is probably of more importance than appeared from the discussion, where it was mentioned only incidentally. It will be generally true, of course, that an amount of attention and care which appears normal and proper to one organization may be burdensome and excessive to another, and naturally the latter will find it necessary to deal with the freezing problem by sheathing, heating, etc., while the other organization reports "little trouble" with almost wholly unprotected tanks.

The results of a rather extensive statistical inquiry made by the committee are presented in full in its report. We reproduce in the following only a summarized abstract of the replies received. The committee was composed of J. P. Canty, B. & M. R. R.; Fitchburg, Mass.; J. Parks, U. P. Ry., Denver, Colo.; A. Findlay, G. T. Ry., Montreal, P. Q.; F. L. Burrell, C. & N. W. Ry., Fremont, Neb.; and K. J. C. Zinck, C. R. I. & P. Ry., Des Moines, Iowa. The various available means of protecting water tanks are represented in practice as follows:

Heating Water in Tanks.—Five members make this a regular practice to prevent freezing of tanks; four do it occasionally; 29 make no attempt to raise the temperature of the water.

Top and Bottom Air-Spaces.—Ten members make no provision for an air-space at either top or bottom of tank; five have used an air-space at top only; one used an air-space at bottom only; 23 use air-spaces both bottom and top; one uses a complete housing-in of the tank (see C. P. Ry. standards below).

The top air-space is formed by: one layer of sheathing and paper on top and bottom of flooring joists which rest on top of tank staves (2 members); one layer of sheathing, without paper, top and bottom of these joists (1); two thicknesses of sheathing, with paper between, on top of the joists (7); one layer of sheathing, without paper, on top of the joists (6); one layer of sheathing, with paper, on top of joists (2); sheathing and paper on bottom of roofing rafters (2).

The air-space on bottom of tank is formed by: two thicknesses of sheathing, with paper between, on bottom of floor joists under tank (2 members); one thickness with paper (3); one thickness without paper (5); two thicknesses of sheathing without paper (3).

Protection of Sides of Tank.—Aside from the one case where full housing-in is practiced, the members appear to find side-protection unnecessary.

Connecting Pump Delivery into Discharge-pipe Between Tank and Stand-pipe.—This expedient, to keep the water in the discharge pipe in circulation and thereby prevent freezing-up in the tank discharge pipe, is practiced by 12, occasionally used by 8, and is objected to by 18 members.

Turning Exhaust from Steam Pumps into Pump Suction-pipe.—Three replies favor this arrangement, 35 do not, and some of the latter specifically object to the practice.

Protection of Hinged Outlet Pipe and Valve.—Where no stand-pipes are used and water is delivered to locomotives

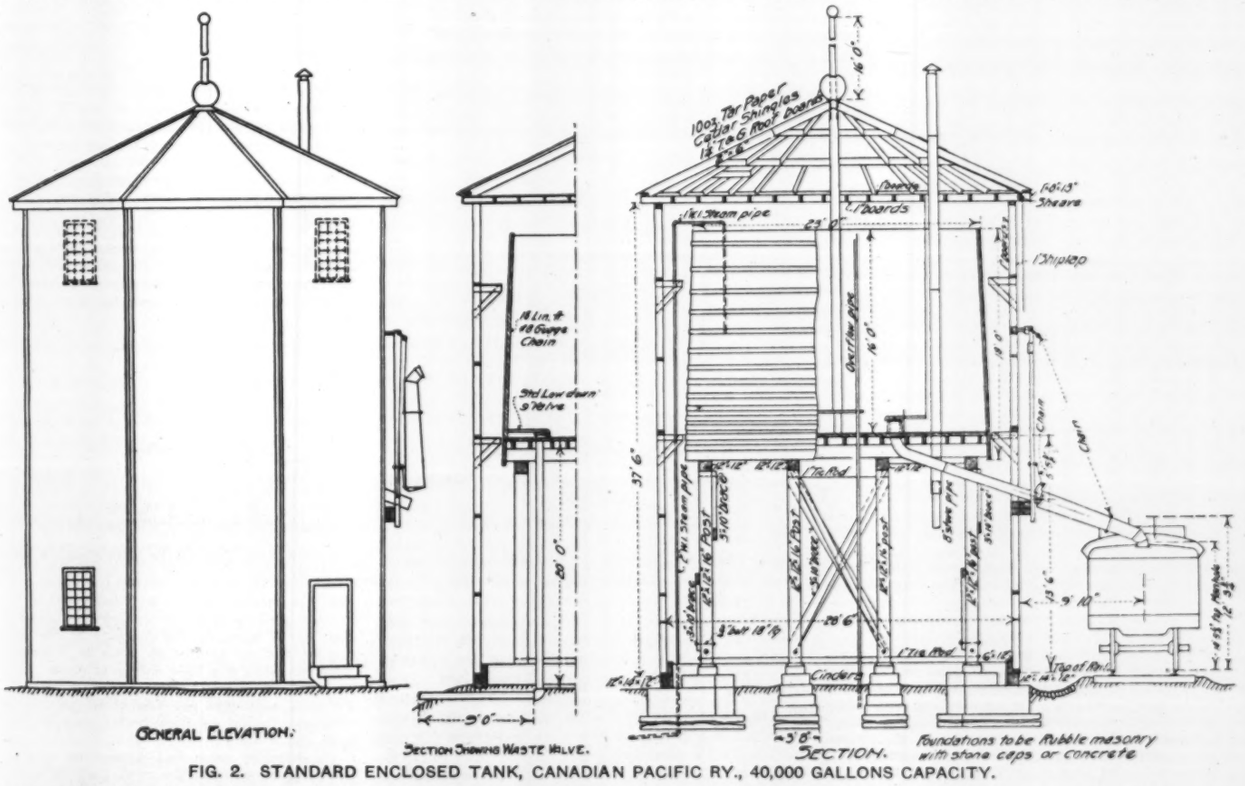


FIG. 2. STANDARD ENCLOSED TANK, CANADIAN PACIFIC RY., 40,000 GALLONS CAPACITY.

through the customary hinged outlet pipe, 14 members provide no special precautions to protect outlet valve and spout from freezing; 11 furnish pipe or hose through which steam may be furnished from pump house or locomotive, as found convenient; 5 box the outlet pipe; 5 provide stoves in boxing under tank to protect same, and one approves of a long-radius outlet pipe.

Protection of Float-valves.—We find that the location of the float valve on tanks, where they are found necessary, varies from ground to top of tank; one member placing it under tank; four on bottom of tank; two think it should be about 1 ft. above the bottom; five give as their choice 2 ft. above the tank floor; one prefers it elevated 4 ft. from floor; nine find that valve works nicely at a point about 8 ft. from same; one approves of 10 ft.; two of 14 ft., and three have found that a float valve on top of tank has given them satisfactory service.

In order to keep float valves operating properly, two members of our association find that their forces have to watch valves closely, and one of our members suggests balancing supply and delivery so as to keep float valve working constantly; two, evidently where water is not metered, use no float valve and permit the water to overflow.

Protection of Pipe Between Floor of Tank and Ground.—Members in practically the same latitude differ as much in their opinion of the best protection for pipes under tanks as they do in the location of the float valve. One uses hollow tile boxing; three are not definite but specify several air spaces; eight build their tanks with one air space; seven with two air spaces; nine find that it is advisable to protect piping under tanks with a boxing having three air spaces; three advocate four tight air spaces, and one thinks it pays to provide five.

Four find it satisfactory, when possible, to run a steam coil on interior of boxing; two save themselves from trouble by providing stoves; one advocates draining pipes; one finds a covering of two layers of sheathing with paper between is ample; one builds his tanks with piping underneath protected with four layers of boards with paper between; one fills box around pipes with sawdust, and another goes a little further and not only fills in around pipes with sawdust but provides one air space outside of the sawdust box.

The committee also refers to the discussion of Subject VI. at the 11th Annual Convention (1901) of the Association for further information on water tank protection.

In connection with the report two railroads presented drawings of their standard water tanks designed to be frost-proof under the conditions of the respective roads. The Pennsylvania R. R. standard tank, Fig. 1, exhibits the use of top and bottom air space protection, with unprotected sides. The water pipes from tank to ground are boxed in for protection; and occasionally steam coils have been used in these boxes. Freezing of the float valve is guarded against by pumping into the tank constantly, so as to keep the water in circulation. The water spouts are sometimes kept clear with steam jet, but generally only by draining and by clearing away the ice as it forms in spout and valve.

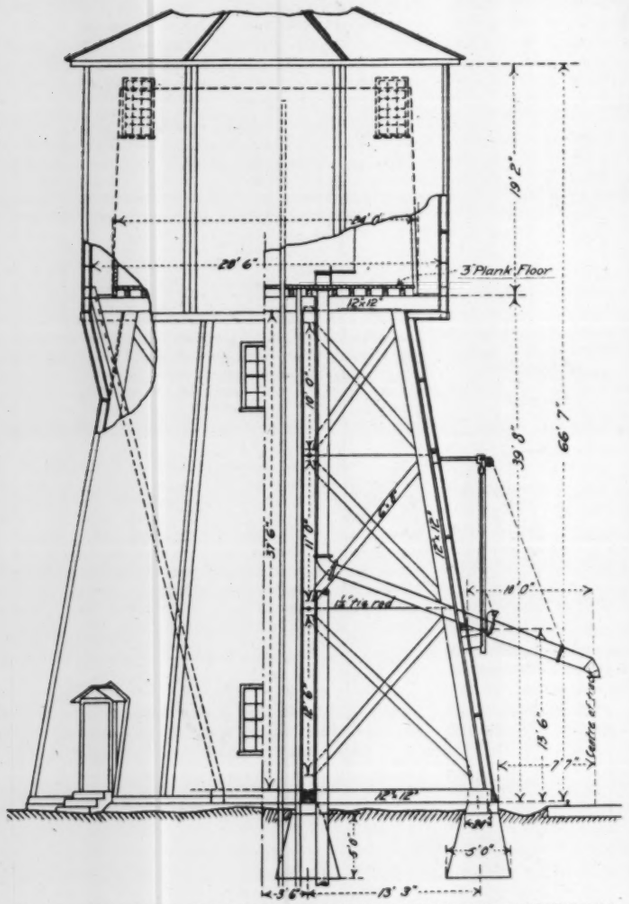


FIG. 3. STANDARD HIGH ENCLOSED TANK, CANADIAN PACIFIC RY., 40,000 GALLONS CAPACITY.

The Canadian Pacific tank, shown in two variations in Figs. 2 and 3, is a completely enclosed af-Fair. Mr. F. P. Gutelius, Engineer of Maintenance of Way, says:

We find it necessary to use heat to prevent water from freezing in all tanks on the system except those on the Pacific coast. Numerous methods are used:

(a) To extend the smoke pipe from the stove under the tank through the bottom of the tank so that the water in the tank is in direct contact with this pipe. In many cases smoke pipe leads from the pump boiler, which is placed underneath the tank; in others a heating stove is used.

(b) When pump is located sufficiently near the tank, the exhaust pipe from the pump is extended into the tank and steam from the pump passes through this pipe, which is a coil, located as shown on plan of enclosed tank.

(c) The substructure of the tank in many instances is a 30-in. stone wall, which keeps the bottom of the tank warm without the use of steam. In severe winters, however, this is not sufficient to prevent ice in tank.

(d) Our new standard tank encloses the entire structure and is sufficiently large to give workmen access to the bands.

In the enclosed tank, a wooden housing surrounds both tank and supporting tower, and is roofed at the top. With this protection no additional insulation of the down pipes is necessary, and, as no floating ice forms in the tank, the float valve is not interfered with. The enclosed tank is said to be giving good satisfaction, except for the accumulation of ice on the track, caused by wasting water when locomotives are being supplied.

VITRIFIED TILE SEWERS AS HOUSE DRAINS IN CHICAGO.

By Perry L. Hedrick.*

Modern scientific effort has been so effectually directed towards the solution of problems affecting the sanitation of populous communities that the neighboring public doubtless does not know that Chicago aldermen are still debating the question as to whether vitrified earthenware sewer tile should even be required to withstand any pressure test when laid. For many years past many towns within the United States have prohibited the laying of tile sewer within the foundation walls of buildings for the purpose of conducting away house sewage. The Sanitary Bureau of the Health Department of Chicago has for a number of years endeavored to secure the laying of house drains under better conditions than have as yet been [illegible]yed. In fact, a number of attempts at vari[illegible]mes have been made to enact into law a mea[illegible]substitut- ing iron for tile sewer pipe, an[illegible]often as presented it has been defeated thro[illegible]he efforts of the tile interests.

At the present time the question [illegible]whether tile or extra-heavy cast-iron pipe [illegible]be used for house drains, but whether the [illegible]pipe shall be subjected to a hydraulic test [illegible]re of 10 ft. head (4.34 lbs. per sq. in.) when [illegible], or shall be permitted to be laid as now with [illegible]perfectly made joints and with little or no in[illegible]tion.

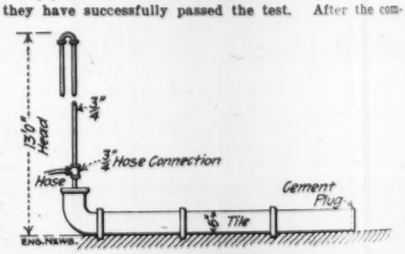
I will say in passing, for the sake [illegible]clearness and to prevent being misunderstoo[illegible]hat to a well-informed and unbiased mind [illegible]e can be little room to question the superi[illegible]r of iron over tile for house drainage purpos[illegible]. A bit of history must be recounted to make [illegible]situation clear.

Prior to the enactment of the Revis[illegible] Municipal Code of 1905 (March 20) all house d[illegible]ins, if of tile (and 99% of them were), were [illegible]id under the supervision of the Sewer Depart[illegible]nt. With the revision of the Code, the supervi[illegible]n, in accordance with the Illinois State Law, [illegible]s placed under the supervision of the Commissioner of Health. In compliance with the City Council's instructions, the re-codifying attorneys were to confer with the heads of the departments for suggestions and changes in the old ordinances. Hence I was commissioned by the Commissioner of Health to offer suggestions for the betterment of the Plumbing and Sanitary Ordinances. In view of the many fights against iron drain pipe, it was considered that if iron was to be substituted for tile, this question should be fought out in the open Council; hence the provision for testing tile drains, if the same were laid within buildings, was the only one to be made. This was the first provision ever made by ordinance to check the use of imperfect materials and the criminal negligence in slovenly workmanship.

The plumbing ordinances of Chicago, 1905, contain the following clause (No. 1,718):

The entire plumbing and drainage system when roughed in, in any building, shall be tested by the plumber in the presence of the plumbing inspector and as directed by him, under either a water pressure or air pressure.

The water pressure test shall be applied by closing the lower end of the main house drain and filling the pipes to the highest opening above the roof with water, except that a part of the system may be tested separately, provided that there shall be a head of water of at least 10 ft. above all parts of the work so tested. The air pressure test shall with a force pump and mercury column equal to 10 ins. of mercury. The use of spring gages is prohibited. Special provision shall be made to include all joints and connections to the finished line or face of floors or side walls, so that all vents or revents, including lead work, may be tested with the main stacks. All pipes shall remain uncovered in every part until they have successfully passed the test. After the completion of the work, and when fixtures are installed, either a smoke test under a pressure of 1 in. water column shall be made of the system, including all vent and revent pipes, in the presence of the plumbing inspector and as directed by him; or a peppermint test made by using five fluid ounces of oil of peppermint for each line up to five stories and basement in height, and for each additional five stories or fraction thereof one additional ounce of peppermint shall be provided for each line.



Test of Tile Drain with Cement Joints.

All defective pipes and fittings or fixtures shall be removed and all defective work shall be made good and so as to conform to the provisions of this chapter.

The customs in vogue as revealed by inspections upon newly laid tile drains are nothing short of criminal, because they present conditions that

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jeopardize human life. As laid under the old regime, alinement and grade are imperfect; little care is exercised in the selection of pipe and cementing materials; there is little or no annular space between the spigot and bell for cement; the cement is omitted from the under side of the pipe, or it is forced into the preceding pipe and left there to harden; the pipe is not properly bedded; bell holes are not made; elbows are placed at times with a space of an inch opening or more on the under side between the spigot end and the bell of the next pipe; the cementing material is at times a mixture of lime, mortar and natural cement of varying quality. Tile pipe laid under such conditions can render little but sieve-like action under back pressure from the main sewers. On account of these very conditions, we find after rains that hundreds of basements and cellars are flooded with from 2 ft. to 3 ft. of sewage. Of the 10,000 complaints received yearly by the Bureau, fully 12½% are occasioned by defective tile sewers.

The importance of a provision to render tile drains safe, in so far as a water pressure test will indicate the same, is clear when it is recalled that during each year at least 750,000 lin. ft. of tile are laid wholly within the building walls for purposes of carrying away house sewage. Hence also it may be seen why the tile interests are so active in endeavoring to defeat any measure that may even cull the questionable tile.

Subsequent to Council order of May 8, so much of the new code as relates to the construction of private sewers or house drains, was referred to the Committee on Judiciary, and the question of changing or retaining the test requirement now rests with a sub-committee of the same. The tile interests have attempted to show: (1) that tile is excluded by the ordinance; (2) that the supervision of construction should be under the Sewer Department (though it is difficult to see why that would be an advantage). The tile interests have also objected to any test.

The Health Department very clearly realizes that the present conditions of the city's sewers is an increasing menace to the public health of the city. The conditions of sewage flooded basements, or of sewage soaked soil beneath buildings, are entirely too frequent to permit of the use of tile sewers as ordinarily laid within buildings. Either the pipe must be placed in such a manner as to render it safe, in so far as the present prescribed water pressure test can be made to determine this, or a remedy must be sought in the use of extra heavy cast iron pipe for house drains. The importance of a test made upon these drains in Chicago cannot be overestimated, and it is proper that this test should be severe enough to insure the employment of a high order of skill and the use of first class material.

The insufficient size of many Chicago public sewers causes frequent flooding and back pressure in the house drains, which is virtually a water pressure test under varying heads of pressure. This produces fractures, discovers defects, and develops leaks in the tile pipe and results in the presence of standing sewage in basements, cellars and surrounding soil.

In this connection it can be properly stated that the gases arising from the leaks and breaks in drains have a positive effect upon all classes of persons breathing them by lowering their vital resistance, and thus increasing their susceptibility to disease. "Children especially suffer in nutrition, and with them febrile attacks may be frequent, but all the power of resistance to such diseases as typhoid fever, diphtheria, etc., is lessened and the susceptibility to them is increased, the sickness is more severe, and the convalescence more prolonged. Indeed, sewer gas and soil air probably aggravate all diseases."

In order that the provisions of the code governing the testing of house drains might be approved properly, I arranged for several tests to be applied to some connected lengths of tile pipe. The accompanying sketch illustrates the arrangement. Three 2-ft. lengths and one elbow of 6-in. Akron pipe, and the same of pipe furnished by the Chicago Sewer Pipe Co., were selected and connected together with Portland cement mortar, made with 1 part Wolverine Portland cement and 1 part fine clean sharp sand. Enough water was used in the mixture to make the mortar plastic, and so that it would easily enter the annular ring left between the spigot of the pipe and the bell. In the hub end of the elbow a ¾-in. cast iron tapped floor-flange was cemented, using a mortar of the same proportions and consistency as is used for the joints. The end of the last tile length was plugged with cement mortar. After the mortar had set for 48 hours, the joints were subjected to a water pressure test under 13 ft. head and withstood the same for a period of 15 minutes without showing water leaks. When the pipes were being filled with water, some of the imprisoned air was forced through the joints in the form of bubbles, but aside from this there was no leakage. The second test under the same conditions was made with the same results. A third test was made by subjecting the pipe to the full city water pressure, which was practically 30 lbs. The joints withstood the pressure.

In this connection it might be noted that it will be necessary in laying a tile drain so as to withstand the prescribed water-pressure test to select uniform pipe and fit the lengths together before laying, in order that sufficient annular space may be left in the hub for the cement material. A number of pipe examined and fitted together showed that if they were used only 15-32-in. annular space would be left. It is necessary that this space be at least ¼-in., or better, ⅜-in., in order that satisfactory work may be done.

A second point to be noted is that better service would be secured from tile sewers if the hub end of the pipes were formed in such a manner that each pipe length when laid would center itself. The joint could be more easily made and with more certainty of security if the hub was made slightly more flaring.

A defect is found in the way elbows are made Examination shows that the spigot has been cut at a springing line. In my judgment it should be cut on a tangent, the depth of the socket from the springing line making the elbow that much longer. The reason for this is obvious, because the way in which they are now cut often renders it impossible to have any cementing space on the upper side of the elbow.

The purpose of the test above noted was to demonstrate to the opposition that a careful workman can easily lay a tile sewer so as to make it water tight and to withstand the specified pressure.

SOME REMARKABLE TESTS INDICATING "FLOW" OF CONCRETE UNDER PRESSURE.

By Ira H. Woolson.*

The accompanying engraving illustrates some rather extraordinary results which we recently obtained in the Columbia University Testing Laboratory while making a series of tests upon different methods of column construction for the American Column Company.

A series of short columns, 4 ins. in diameter, and 12 ins. long, were constructed by filling steel tubes of that size with a finely crushed stone concrete and allowing the same to set. The concrete in the columns tested was 17 days old at time of test and appeared to be very hard. The metal of the tubes was of different thicknesses, varying from ⅛ in. to ¼ in. The heavier metal columns carried a load of 150,000 lbs. without injury except a slight shortening of less than ¼ in. The columns with the light weight tubes began to show a marked deformation at about 120,000 lbs. and this gradually increased until a load of 150,000 lbs. was applied, when the tests were discontinued. The photograph shows what happened in different cases. No. 1 was unaffected by the full load, No. 2 had sustained a load of 115,000 lbs. A bulging ring near the top and bottom shows that failure had just begun. Nos. 3 and 4 show excessive deformation due to increase of load. They were compressed 3¼ ins. and 3½ ins., respectively. The diameter had correspondingly increased to about 5 ins.

It was supposed that this excessive distortion had completely disintegrated the concrete and left it a powdered mass, but to our surprise when the tube was sawed apart and removed, the concrete was found to have taken the exact shape of the distorted tube and was as solid and perfect in every way possible.

The proof was positive that the concrete had actually flowed under the pressure like any plastic material. The concrete was apparently perfectly dry, and the pressure produced no sign of moisture anywhere.

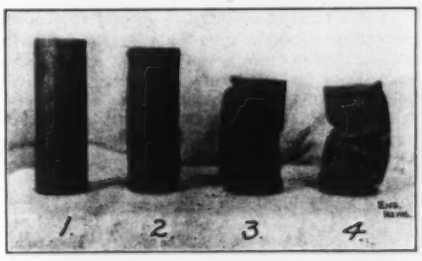
In 1901, Professor Frank D. Adams, of McGill University, presented a paper before the American Geological Society in which he described some results he had obtained by compressing 1-in. cylinders of marble in steel tubes. He caused the cylinders to become larger and shorter by actually compelling the crystalline marble to flow. So far as known, these present tests are first evidence on record that concrete could be made to show this remarkable phenomena of flow.

It furnishes "much food for thought." May not large masses of concrete foundations surrounded by more or less yielding earth do the same thing when subjected to excessive pressure?

From a geological standpoint the phenomenon is also interesting as illustrative of the way various rock formations were folded and distorted after they were formed.

We plan to make further tests in this line upon concrete several months old and see if it still possesses the same mobility.

In your issue of Oct. 12th, Mr. C. A. P. Turner, in a letter discussing the properties of concrete,



View Showing Distortion Under Pressure of Steel Cylinders Filled with Concrete Without Fracturing the Concrete.

says: "Experiments on the crushing of concrete have been confined largely to crushing between forces applied to two opposite faces of a cube and the results that may be obtained by applying equal compressive stress to four sides of a cube are not on record in engineering works." It would seem that these results might throw some light in the direction of this missing information.

*Adjunct Professor of Mechanical Engineering, Columbia University, New York City.

MUNICIPAL OWNERSHIP IN AMERICA AND Europe is to be investigated under the auspices of the National Civic Federation, 281 Fourth Ave., New York City. The study has been entrusted to a committee of 21, including Dr. Albert Shaw, Editor of the "Reviews of Reviews" New York City; Mr. Talcott Williams, of the editorial staff of the Philadelphia "Press;" Prof. Frank J. Goodnow, of Columbia University, New York City; Prof. Edward W. Bemis, Superintendent of Water-Works, Cleveland, O., and Dr. Milo R. Maltbie, of New York City, formerly Editor of "Municipal Affairs." The last three are on a sub-committee to formulate a plan for the investigation.

A NEW PASSENGER TERMINAL STATION at Chicago is likely to be built in consequence of the decision of the courts granting to the Sanitary District certain land along the river beside the present Union Station. The land is at present occupied by freight houses and freight and passenger tracks and its ownership has been in dispute for some years, as it is required for the widening of the river. The present Union Station is occupied by the Pittsburg, Ft. Wayne & Chicago Ry., Pittsburg, Cincinnati, Chicago & St. Louis Ry., Chicago, Burlington & Quincy Ry. and the Chicago, Milwaukee & St. Paul Ry. It is thought possible that the new station will also be used by the Baltimore & Ohio Ry. The cost of the new terminal, including land, station and buildings, tracks and other facilities is estimated at $10,000,000 to $15,000,000.

PROPOSED CONCRETE FLOORS FOR RAILWAY BRIDGES AND TRACKS.

By J. W. Schaub,* M. Am. Soc. C. E.

In Engineering News of Jan. 5, 1899, the writer published an article describing a form of concrete roadway under the title of "A Design for Permanent Track for Steam Railways," which was published, not with the idea of having anyone adopt it outright, but more with a view of bringing forth some discussion on this subject. Since then the subject has come up in another way and the original design has been modified accordingly.

In connection with a long viaduct the writer proposes to do away with all ballast and cross ties and rest the track rails on a longitudinal timber, which is bolted to a concrete floor. Referring to the original cut published in 1899, it will be seen that the design now proposed is practically the same as it was then, excepting that the rail now rests upon a longitudinal timber, instead of resting directly on the concrete. Tie plates are to be inserted under the track rails for two purposes, one to distribute the load properly on the timber and the other to drain the space between the track rails by permitting the water to flow out under the rails. Screw spikes are to be used instead of ordinary spikes. These spikes are now made by the Oliver Iron & Steel Co., and have been adopted by the South Side Elevated Ry. in Chicago, the first to be put in use in this country other than experimental. The writer understands also that one of the large Western roads is about to adopt this form of spike. In any event, the use of creosoted timber for cross-ties will soon bring this spike forward into general use.

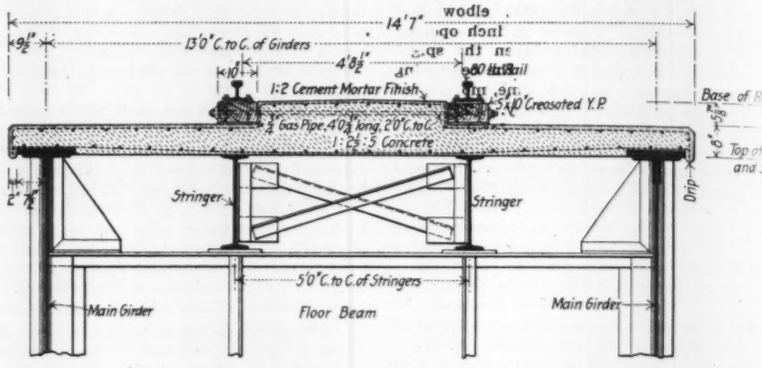
As this form of track is of general application, the writer presents herewith a drawing showing its application to deck and through span bridges, as well as for an ordinary roadway. For tunnels and bridges, particularly, it is a mere blind following of past precedent to lay track rails on cross-ties. When this problem has been solved for such structures the cross-tie will soon disappear.

The floors proposed for bridges need no explanation. The necessity of some form of solid floor for bridges has long been known, and all sorts of schemes have been resorted to, but all with the view of using cross-ties for supporting track rails. Some exceptions may be noted as to this, but only to a limited extent. With the use of the cross-ties goes the ballast, and with the latter go all the ills that go with the attempts to make the bridge floors waterproof. Some engineers will tell you that they have succeeded in making bridge floors waterproof, but all such attempts can be answered, in the light of our present knowledge, by saying that unless such floors are made of concrete, or some other indestructible material, or unless such floors are properly drained, the moisture will be retained by the ballast, and this will ultimately destroy the floor. There are some excellent illustrations of this fact here in Chicago among the recent structures in connection with the track elevation work.

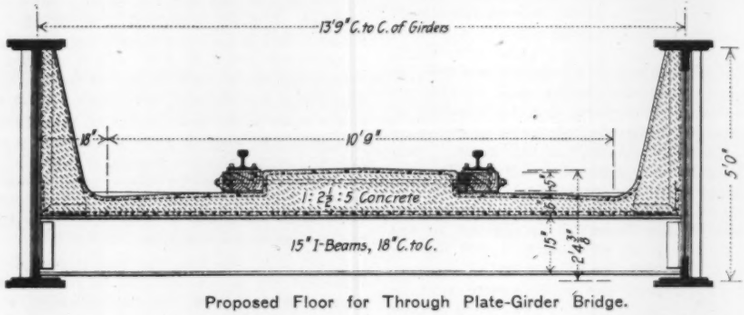
As to the cost of such floors the first question appears to be, does not the increased weight of the floor itself add materially to the cost of the bridge? Not at all, when proper allowance is made for impact, or rather for the diminished impact and vibration due to the increased dead load. In other words, impact formulas are in use which depend upon the relation between the fixed load and a moving load to such an extent that for bridges with ballast floors no increase in the amount of metal to be used is necessary. As to the floor itself, such floors can be built for less than one-half the cost of buckle-plate or flat-plate floors, and when the maintenance and renewals are considered, such floors will cost no more than the ordinary open floors, to say nothing about the advantage of having a floor which is proof against fire, and also against the drip of salt water from refrigerator cars and derailments.

The proposed concrete roadway, however, needs some explanation. It is intended only for roadways long in use and well drained. It is proposed, first, to build a substructure of rubble concrete. This in some cases may have to go deeper than shown, and in other cases may have to rest on a foundation of concrete piles. In other words, the substructure must rest upon a foundation which is well drained and free from the effects of frost and thawing in winter weather. After the substructure is built, and after the same has been in use for some time, with the ordinary ballast and track, the ballast and track are to be removed, the rubble concrete is to be made level with a bed of mortar, upon which the concrete floor is to be placed in sections. The floor is then ready for the longitudinal timber and the track rails, provided the bed of mortar has had sufficient time to set. Such a floor if properly constructed should require no renewals excepting the timber upon which the track rails rest.

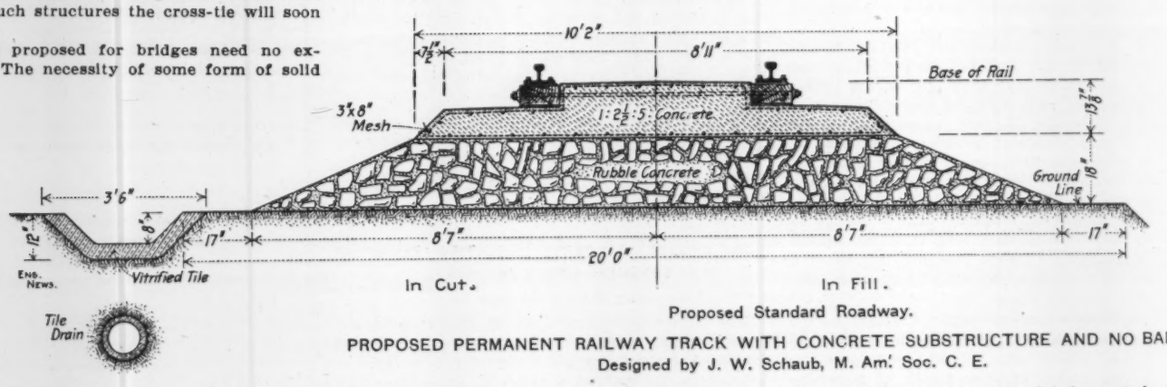
As to the cost of such a floor, the estimates published by the writer in Engineering News of



Proposed Floor for Deck Plate-Girder Bridge.



Proposed Floor for Through Plate-Girder Bridge.



Proposed Standard Roadway.

PROPOSED PERMANENT RAILWAY TRACK WITH CONCRETE SUBSTRUCTURE AND NO BALLAST.
Designed by J. W. Schaub, M. Am. Soc. C. E.

Jan. 5, 1899, and reproduced below, apply in this case also.

The cost of such a track and roadbed, as compared to the present form, is as follows, leaving out the cost of the track rails in both cases:

Permanent Track.

Material.			Cost per mile.
Broken stone	2,000 cu. yds. at	$1.00	$2,000
Broken stone concrete	830 " " "	5.00	4,150
Gravel concrete	1,100 " " "	5.00	5,500
Tie rods and nuts	3,520 each "	.35	1,232
Steel wire, laid	10.89 tons "	30.00	327
Rail splices			580
Turned bolts			100
Laying track			2000
Incidentals			191
Total			$14,080

Present Track.

Material.			Cost per mile.
Broken stone	3,000 cu. yds. at	$1.00	$3,000
Ties	3,000 each "	.60	1,800
Tie-plates	6,000 " "	.08	480
Rail splices			580
Bolts and spikes			100
Laying track			2000
Incidentals			80
Total			$8,080
Cost of permanent track per mile			$14,080
Cost of present form of track per mile			6,080
Extra cost of permanent track per mile			$8,080

*Consulting Engineer, Monadnock Block, Chicago, Ill.

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ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
"Proposal": $2.40 per inch.
"Want": See pages 26 and 27.

Copy for regular, or "Contract," Advertisements should be received one week before publication; "For Sale" and "Situations Wanted" Advertisements by Tuesday, and "Proposal" and "Situations Open" Advertisements by 11 A. M. Wednesday.

Entered at the New York Post-Office as Second-Class Matter.

An important general order has recently been issued by the Secretary of War, Hon. Wm. H. Taft, relating to the letting of contracts in the War Department, and of the bonds by which such contracts are guaranteed, and the inspection necessary to insure the fulfilment of the contracts. We think it worth while to print the order in full, as follows:

With a view to a thorough enforcement of the laws which require that all supplies for the Army shall be purchased "where the same can be purchased the cheapest, quality and cost of transportation and the interests of the Government considered," and that "such contracts shall be made with the lowest responsible bidders," the following instructions are published for the information and guidance of officers charged with the procurement of supplies for the several branches of the military establishment, and strict compliance therewith is enjoined, viz.:

1. Advertisements for supplies should contain the instruction to bidders, who are not manufacturers of the goods called for, to submit the name of the manufacturer from whom such goods are to be obtained, unless it be manifestly impracticable to furnish this information.

2. Lack of commercial standing on the part of the bidder or inadequate facilities or plant on the part of the manufacturer will constitute good and sufficient grounds for the rejection of bids. Abnormally low bids should be subjected to the strictest scrutiny and comparison with prevailing market rates.

3. All bids received from contractors who have failed unjustifiably to fill former contracts with the Government shall be rejected.

4. Careful investigation will be made of the financial status of individual bondsmen offering themselves as sureties on contractor's bonds, and no bonds of individuals will be accepted until it is conclusively shown to the satisfaction of the contracting officer that such bonds afford ample security to the United States for the fulfilment of the undertaking in question.

5. Contracts once executed will be strictly construed and no variation from standards or specifications will be permitted or authorized. If it be demonstrated that contract requirements are unreasonable, or that the prescribed tests are not practical, or that for any reason the stipulations can not be rigidly applied or enforced, such contract must not be modified but may be annulled with the approval of the Secretary of War, if for the best interests of the Government; and after again inviting competition from bidders, who are fully informed of the changed requirements, a new award and contract can be entered into. To sanction variations or to relax stringency in any particular of an existing contract is irregular, and is likely to give the contractor an advantage which is unfair to competitors whose proposals were based on the expectation of being held to the strictest observance of the published requirements.

6. Raw material used by manufacturers in furnishing finished products will be as frequently inspected as the interests of the Government may require by inspectors especially qualified for such work, subject to frequent personal supervision by a commissioned officer.

7. All supplies furnished under contract or otherwise will be subjected, whenever practicable, to the personal inspection of a commissioned officer at the time of delivery; otherwise such inspections will be made by civilian inspectors under his personal supervision subject to test and verification at irregular intervals and at unexpected times by such officer.

8. Commissioned officers charged with such inspections and with the supervision of civilian inspectors must qualify themselves by study, observation, and practice for such supervision as shall effectively protect the Government interests.

Wm. H. Taft, Secy. of War.

War Department, Washington, Oct. 6, 1905.

So far as we can see the above rules would apply admirably to municipal work or to work done for a private company, as well as to work for the United States. It is poor business policy to let a contract to a party with no commercial standing, with bondsmen of doubtful responsibility, or with a bad reputation gained by fortunes on previous work. Even though such a contractor may be a low bidder, experience shows that the work he will perform will be dear in the end.

The general rule regarding inspection is also worthy of particular notice. Systematic inspection of all purchased material is a practice of very recent origin, and it is only a few corporations with the most highly systematized organization that have adopted it. That it is a necessary concomitant of the purchase of materials by specification on open competitive bidding is, however, beyond question; and it is certain to be extended very rapidly as business becomes more and more concentrated and is carried out on a larger and larger scale.

American steel rails rolled in Buffalo by the Lackawanna Steel Co. are to be carried 500 miles to the seaboard and thence by ship to Australia, and there delivered for a contract price of £5 13s. 6d., or $27.61 in American money. The contract as reported in the London "Times" calls for 6,282 tons of steel rails and 261 tons of fish plates, the price of the latter being £895 per ton, or 1.75 cts. per lb. It is said the contract price is only made possible by the prevalence of exceptionally low ocean freight rates between New York and Australia, and this rate must indeed be very low to enable a manufacturer to deliver his goods at a foreign port in the Antipodes for a smaller price than he receives from home consumers.

It may be thought surprising that such a contract as this should be made at a time when there is an urgent demand in this country for all the rails that American mills can produce, and when, in fact, the rail mill capacity is said to be sold out until well toward the close of 1906. The answer which is given in justification of such contracts is, that in order to hold our foreign trade it should be taken care of regardless of fluctuations in the home market; and that, as orders from abroad are a very valuable support to industry in times of depression, it is good business policy to look after foreign markets, even when our own home market is in an active condition.

This rule, however, is not always applied. For example, it has come to our knowledge, during the present week, that a French architect of international reputation has just been spending some time in this country endeavoring to let a contract for furnishing about 9,000 tons of structural steel. The deliveries were to extend over a period of four or five years, and the conditions of the contract are said to have been very attractive. It was found impossible, however, to find an American firm willing to name any moderate price on the contract, and after an unsuccessful search the architect has decided to return and let the contract in Europe. If the contract had called for immediate delivery, it would be easy to understand why it should show no attractions to American bidders at the present time; but in view of the length of time over which deliveries were to extend, it is quite surprising that some faint reflection of the policy indicated in the steel rail contract above noted was not applied in the case of the structural steel work.

The advance sheets of Poor's Manual for 1905, showing the general results of railway operation for the fiscal year 1904, are of much interest in connection with the current public discussion respecting railway rates and Government control thereof. The average freight rate per ton-mile for the whole United States was at the lowest point in 1899, when it was 0.726 ct. Since then it has increased each year and in 1904 it reached 0.787 ct. The average passenger rate per mile has also advanced from 1.994 ct. in 1898 to 2.053 ct. in 1904. Coupled with this advance in rates there has been a large increase in the volume of traffic. The tons of freight moved, which was 788 millions in 1897, became 1,277 in 1904, and the ton-miles of transportation increased in even greater ratio. These two factors have combined together to increase greatly both the gross and the net earnings per mile of road. In 1894 the average gross earnings per mile were $6,054, and the net earnings averaged only $1,803. In 1904 these figures had advanced to $9,248 for gross and $2,989 for the net.

It will be seen, therefore, that out of an increase of about $3,200 per mile in gross earnings, nearly $2,000 went to pay the increased operating expenses due to handling the increased business, and in part also to higher rates for wages and higher prices for materials, leaving about $1,200 increased revenue for the owners of the road.

Turning now to the statistics of payments on securities, it appears that nearly all of this increase in net revenues has gone to benefit the stockholders. The average rate of interest on all outstanding railway bonds has fallen from 4.19% in 1894 to 3.98% in 1904. As a result, notwithstanding an increase of over $2,000,000,000 in the amount of bonds outstanding, the interest payments only increased $41,000,000, while the dividend payments, which were $83,000,000 in 1894, had grown to $211,000,000 in 1904. The average rate of dividend on all outstanding railway stocks, which was only 1.66% in 1894, increased to 3.31% in 1904. This is a higher rate of average dividend than American railway stocks have paid for very many years. In 1883, the average rate of stock dividend was 2.76%, but this steadily and rapidly fell, reaching 1.80 in 1888, and bottom was touched with an average rate of 1.51 in 1897. Since that time there has been a steady and rapid increase in the average dividend rate every year.

We give large space in this issue to a document full of interest to every engineer and contractor—the official report of the expert engineering commission which has been at work for some months investigating the contract work done for the City of Philadelphia in the construction of its new filtration system. The Commission was made up of Major Cassius E. Gillette, of the U. S. Engineer Corps, Mr. John D. MacLennan, M. Am. Soc. C. E., of Washington, D. C., and Mr. Wm. Barclay Parsons, M. Am. Soc. C. E.; but Mr. Parsons has been prevented from acting on the Commission of late by his work on the Panama Canal Consulting Board.

We will not take space at this time to comment on the report and the state of affairs which it uncovers. But it will certainly recall to engineers of an older generation how another distinguished officer of the Corps of Engineers, the late Gen. Wm. Ludlow, more than a score of years ago, was placed in charge of the Philadelphia water department and inaugurated a period of honest administration there, to the great discomfiture of the ring of politicians and favored contractors who had been heaping up fortunes at the taxpayers' expense.

To Major Gillette more than any other one man was due the exposure of the Savannah Harbor frauds, and it was his thorough work in investigating the methods of the conspirators that resulted in Carter's final conviction and imprisonment and the flight of the contractors to Canada, from whence after long delays they have just been extradited and brought back to the United States for trial. It is said that Secretary of State Root, who was formerly employed by Mayor Weaver as counsel, was instrumental in securing for the City of Philadelphia the services of Major Gillette to investigate the filter contracts.

The report which is printed in this issue speaks for itself; and suggests the thought that Major Gillette's name is likely to be as great a terror to dishonest contractors as is the name of District Attorney Jerome to violators of the law in New York City.

The New England Water-Works Association proposes to supplement its recent valuable symposium on the use of copper sulphate for the protection and improvement of public water supplies by a tabulated summary of the experience had with that agent in various parts of the country.

To that end it has prepared a blank inquiry form, which we reprint elsewhere in this issue. The symposium (see brief abstract, Eng. News, Sept. 21, 1905) and the supplementary matter will be published soon in the Journal of the association. We bespeak hearty cooperation in this commendable effort.

MUNICIPAL LOAN PURPOSES AND PERIODS IN ENGLAND AND IN THE UNITED STATES.

How many municipalities in the United States adjust the terms of their bond issues to the lives of the corresponding public improvements? No definite answer can be given, but the number is certainly small and the principles governing the adjustments are crude in both theory and application. The foregoing question has been suggested by the perhaps over-elaborate provisional schedule of purposes and periods for which municipal loans are allowed by the Local Government Board of England and Wales. This schedule, which is reprinted below, includes some forty main heads and numerous sub-heads under which municipal loans are classed and analyzed as to the probable life of the objects of the loans. While our primary interest is now with the loan periods we may note in passing that the schedule indicates the great number and variety of municipal undertakings in England as compared with America. Considering these manifold and diverse activities it is less surprising that there should be far more central administrative control of municipal indebtedness in that country than in our own. But while our loan purposes have far less range than those of British cities and towns our municipal areas are so large and our provisions for meeting certain elementary and general municipal wants are on so lavish a scale, as, for instance, our public water supplies, that municipal indebtedness in the United States attains proportions that are magnificent or appalling, according to one's point of view. Our own viewpoint is optimistic, but nevertheless we feel that there are serious deficiencies in the principles which are supposed to govern our municipal bond issues and not a few lapses in the observance of such principles as have obtained recognition. Beyond more or less vague general principles we have not passed and of unanimity in practice we have little. It must be remembered that we refer to a single phase of municipal bonds: their life, or the period for which they are issued.

The main principles affecting the life of municipal bonds in the United States are based on: (1) Attractiveness to investors, who at bond sales are generally represented by brokers; (2) convenience to the municipality, as represented by certain of its officials; (3) justice to succeeding generations and prudence on behalf of the present generation, looked after to some extent by municipal officials and to a degree varying with place and time by that vague but potentially mighty force known as public opinion.

Investors, as a rule, favor a long-term bond, since it affords a permanent investment, and that, too, at a fixed rate of interest during a period of probable decline in the interest rate. Many investors, however, are glad to buy short-term bonds, thus affording an opportunity for re-investment in accordance with possible changes in conditions in the business world or in their own affairs.

The convenience of the municipality as regards the life of bonds is governed by numerous and variable local and temporary conditions. In general, there is a desire to postpone repayment as long as is reasonably possible, in order to distribute the burden lightly over a period of years. But recently a falling rate of interest and more particularly, perhaps, the burdens and temptations of sinking funds have combined to favor short-term bonds, payable a few years from date in yearly instalments.

Justice to succeeding generations, obviously, demands that the needs of the present generation should be met by it, while prudence in behalf of the present generation demands with even more force that attempts to postpone payments far into the future should not lead either to (1) the accumulation of mountains of debt to impair, by their hugeness and their interest charges, the credit of the city, nor (2) the necessity of a second, or possibly a third, bond issue for renewing public works whose lives were shorter than the first bond issues therefor.

All things considered, there should be no hard and fast rules governing the life of municipal bonds, but there should be a well-conceived effort to establish and follow principles designed to make the life period of each bond issue attractive to investors, convenient to the municipality, just to future taxpayers, and in accord with motives of prudence and moderate conservatism on the part of the present generation. These various interests can be served without material conflict and still give flexibility for the adjustment of loan periods to local and also to temporary conditions. On the one hand, the ever-increasing value of real estate and the long life of some public improvements give plenty of scope for as long-term bonds as are demanded for investment or as are warranted by a just regard for the future; while, on the other hand, such short-lived improvements as pavements and garbage furnaces will provide the money market with a sufficiency of short-term bonds. Or the equivalent of both long and short term bonds may be combined in a single issue, redeemable in yearly instalments after five or more years and continuing to final extermination at 20 to 30 years.

It would be interesting, but perhaps more interesting than profitable, to know just how far the principles outlined above are accepted and followed in the United States. To obtain such information would involve a vast amount of searching through State constitutions and statutes, including among the latter general and special city charters and enabling acts in order to find what restrictions our fifty odd commonwealths have placed upon their creatures, the municipalities; an even more extended, more laborious, and more minute, search through municipal ordinances would be required to learn how the thousands of American municipalities have exercised such liberties regarding loan periods as have been granted to them. The net result of this search of constitutions, statutes and municipal ordinances would reveal nearly every possible variation in practice, but no generally accepted and at the same time well formulated rules.

On the whole, however, we think it would be found that the interests of all parties concerned had been fairly well conserved except in the matter of so adjusting the life of bond issues as to make them conform with the life of the corresponding improvements. Included in this exception would be not only over-long-term bonds, but also failures to redeem bonds when due. Such failures necessitate refunding bonds, which are not infrequently issued in such a manner that the original purpose for which the debt was incurred is absolutely forgotten. A still less excusable and perhaps more pernicious practice is the issuance of "general fund" bonds to cover various classes of improvements, thus eliminating at the very outset all possible thought of relationship between the life of the improvement and that of the loan. This practice, it appears, has been limited to a few cities and is not so much in vogue now as formerly.

The great diversity of American practice as regards the life of municipal bonds has already been partly explained by a reference to the fact that the subject is wholly within the control of the several States, that there are some fifty of these, and that few, if any, of them have taken measures for uniformity or for much intelligent systematic control of any sort within their own boundaries. Without going into further detail, since the situation is well known by our American readers, and since our foreign readers can understand it sufficiently well for the purposes of this discussion, we may turn to the great contrast afforded by the central control of municipal loans in England and Wales, first outlining that control in its broad relations, next citing the loan periods generally allowed for the several classes and subclasses of public works, and finally viewing this loan-period schedule with relation to the possible application of some of its features to the municipalities of the United States.

Nearly all municipal bond issues in England and Wales are controlled with a strong hand by the Local Government Board. This control covers all expenditures for permanent improvements except (1) those sanctioned by special act of Parliament, to secure which is generally a tedious and costly proceeding, and (2) improvements made from yearly revenues. The latter, however, may in some cases be anticipated for a few years by borrowing money on a mortgage on the future revenue, to be repaid from the yearly revenue.

Apparently by far the larger part of the municipal capital expenditure is met by so-called permanent loans, subject to the approval of the Local Government Board. Before such loans can be obtained the would-be borrowing municipality must apply to the Local Government Board for a sanction of the proposed loan. As this sanction really involves approval of the scheme in all its details, as well as of the loan itself, the petition must be accompanied by plans of the proposed work. Before the petition is acted upon, a public hearing is advertised and held. At this hearing taxpayers and representatives of the municipal government may be heard and expert witnesses may be called. Interested manufacturers or contractors, desiring to promote the proposed scheme or any of its parts, have no legal standing at such hearings, but may be given the privilege of addressing the inspector or inspectors of the Local Government Board "sent down" to conduct a hearing. After a hearing, which may occupy a number of days, the inspector makes a report to the Board, recommending the refusal or the sanction of the loan; and if the sanction, then with or without modifications of the terms of the loan and of the details of the proposed work. This report is then sent by the inspector to the department which he represents (engineering or medical or architect's, etc.), depending on the nature of the work. After the findings have been sent in turn to all the coordinate departments concerned and opinions have been added thereto, the mass of evidence and conclusion is then returned to the department which held the inquiry. An examination of all the evidence is then made and, if deemed necessary, the findings are sent to those higher in authority, until they may at last reach the President of the Board. When a final conclusion is reached a secretary notifies the municipality that its petition has been granted (conditionally or unconditionally), or returned for amendment or denied altogether.

Many other interesting features of the Board might be discussed, such as its never meeting as a whole, its connection with the general government by having a Member of Parliament as President, and also having a Parliamentary Secretary, but we are concerned here with the general practice of the Board as to the period for which loans for various purposes are allowed. Through the courtesy of Mr. F. J. Willis, of the Local Government Board, Whitehall, S. W., London, England, we are enabled to give the following interesting detailed information on this subject:

List of the principal objects for which the Local Government Board sanction loans, with the periods *usually* allowed for repayment:

	Years.
Baths—Swimming baths	30
Turkish and slipper baths	20
Boats—Steam launches, ferry boats, barges for removal of refuse, &c.	10-15
Bridges—Substantial or stone	30
Of lighter construction	15-20
Buildings—Houses for working classes (maximum)	60
Other stone or brick buildings	30
Sheds and shelters	10-20
Furniture, fittings and equipment	5-15
Carts and vans	10
Clocks (public)	10
Conveniences—Underground or brick structures	30
Iron or other urinals	10-20
Culverting watercourses	30
Costs of local acts and of promoting or opposing provisional orders	5
Disinfecting apparatus (apart from building)	10
Electric lighting—First installation	25
For additional works after the undertaking is established the following periods are given:	
Cables, transformers (other than motor transformers), switches and switchboards	30
Dynamos	20
Motor transformers and instruments	15
Accumulators and arc lamps	10
Rewinding dynamos	10
Electric lighting of large public buildings:	
With complete installation in separate buildings	25
Without generating plant	10
Esplanade (marine)	20-30
Fencing	10-20

Fire brigade purposes, engines, escape, ladder, &c., telephonic communications for fire extinguishing purposes, alarms, call bells, &c	10
Gas—Purchase of existing undertaking—up to	30
Gasometers, tanks, hydraulic mains, condensers, scrubbers, mains, governors, coke stage, tar well	30
Purifiers (boxes and covers), exhausters, station meters, washers	20
Sulphate plant, benches, photometer, testing appliances	15
Stoking machinery, meters, cooking stoves (for fire), lamps and columns, working capital	10
Retorts	2
Heating apparatus—baths	10
In other cases—where cost is proportionately small allowed as part of building.	
Horses and harness	5
Hospital—ambulance and vans	10
Floating hospital	20
Hydrants	20
Land—Purchase. Under housing of working classes acts	60
Otherwise where act allows	80
Laying out, planting, pathmaking, &c. (e. g. in connection with allotments,* cemeteries and pleasure grounds)	20
Library—Books	5
Lighting streets—Lamps and pillars of all kinds	10
incandescent gas burners and fittings	5
Machinery	10-15
(in exceptional cases of heavy and durable machinery.)	20
Markets—Purchase of rights (where act allows)	60
Pens, paving	20
Brick stalls	30
Pleasure grounds and open spaces:	
Artificial lake	30
Greenhouse	up to 20
Seats, swings and gymnastic appliances	10
Private street improvement: The period allowed corresponds to that which the local authority allow the owners for repayment, but it does not generally exceed 7 years.	
Refuse destructor (apart from the building)	15
River walls (according to situation)	20-30
Sea Defences—Groynes (concrete)	20
Groynes (timber)	10
Sea walls	20
Sewerage and Sewage Disposal:	
Sewers and surface water drains and ordinary works of sewage disposal such as tanks, filters, etc. Sewage lifts	30
Ejectors	15
Sludge presses	10
Farm stock	5-10
Steam rollers, stone crushers and scarifiers	10
Streets (new) first formation	20
Street improvements—excavation and filling	30
Concrete foundations	20
Granite paving	20
Wood paving (hard)	up to 10
" " (soft)	5
Sanitary block or asphalt paving	10
Macadam	5
Curbing and channelling	15-20
Trees on roads	10
Footways—Ashes	5
Gravel	5
Tar	10
Asphalt	10
Concrete laid in situ (without strips)	10
" " " (with strips)	15
" slabs (made under pressure)	20
Brick	10
Blue brick (ordinary)	15
" (best)	20
York flagging	20
Cheap artificial stone	15
Superior artificial stone (Victoria, Granolithic, Imperial, &c.)	20
Subways	30
Telephones (complete service)	25
Water Supply—Mains and pipes, reservoirs, water towers	30
Experimental works (boring)	5†
Waste water meters	10
Purchase of existing undertaking	up to 30
Weighing machine	10

*Allotments are small plots of land assigned to so-called laborers for gardening purposes.

†Period subsequently increased to 30 years as regards outstanding balance of loan in the event of an adequate supply of suitable water being obtained.

As may be seen, the general range of loan periods is from 5 to 30 years, with single exceptions of 2 years and 80 years at either extreme and a few 60-year periods. The two-year period is for gas works retorts; the 80-year period for all but one class of land purchases; and the 60-year for certain buildings, for market rights and for land purchases under the Housing of the Working Classes Act.

However inapplicable to American conditions many details of this schedule may be, and however strongly most of our municipalities might object to such minute central control of their debt-incurring functions, there can be no denying the wisdom and justice of the broad principle involved; *the life of bonds should never exceed that of the works for which they are to pay.* Under present conditions American cities need scarcely carry the principle so far as to issue either 2-year or 80-year bonds. There is, however, much to be said for very long-term bonds to meet the cost of lands which will almost certainly be devoted to perpetual municipal use and which through foreseeable causes will never deteriorate in value. But 80 years is so long a way into the future of even a never-ending municipal existence that other factors than the life of the object to which bonds are devoted must be considered: chiefly changed conditions in the money market and the avoidance of obligations extending over so many generations. The relation of such very long-term bonds to total municipal indebtedness would not greatly concern American cities, since their aggregate would be relatively small.

The two-year bond period already mentioned occurs but once in the list, and, being for gas retorts, has practically no parallel in the United States. The list includes numerous instances of five-year bonds. Most of these would be obviated in the United States by either assessments for benefits or the provision of funds by direct yearly taxation, as notably in the case of street paving; others would be merged in a general issue covering various parts of an improvement, like water-works, and providing for a bond period corresponding to the average life of the whole works; or the bonds for the whole improvement could be made payable in yearly instalments, beginning, if need be, with the third or even the second year after their issue. It will be observed that the aggregate cost of the several parts of new electrical instalments may be lumped in one 25-year bond issue and that in the purchase of gas works from private companies a single bond issue may be made, varying with local conditions but not exceeding in life a term of 30 years.

Whatever American cities may think about so minute a classification of life periods of municipal bonds the schedule under consideration unquestionably abounds with suggestions regarding the life of various parts of municipal works, and for that matter of many classes of privately owned works as well. These suggestions relate to depreciation allowances in making valuations of property and in comparing alternate designs for public works. The schedule affords many striking illustrations of how short-lived are numerous objects of municipal expenditure; and also of how very extensively British municipalities resort to loans where American municipalities pay as they go. Doubtless the opponents of municipal ownership would argue that this is a direct and deplorable result of what many of them take pleasure in calling municipal socialism. We think, however, that the chief cause for this difference lies elsewhere; much of it, we presume, in the general absence of frontage or other assessments for local benefits, and also in the practice of levying taxes on the rental value of property, instead of its value at sale, and of collecting taxes from lessees instead of from the owners of real estate.

Turning from this digression to the subject of State control of bond issues, through central administrative bodies similar to the Local Government Board, we would say first of all that something of the kind, but less arbitrary and less minute in its possible exactions, is desirable in the United States and is bound to come sooner or later. It is most needed and will come quickest in the thickly populated states, and for a variety of reasons which we cannot enumerate now, it will probably come first in the Central States. Its object will be the conservation of all the interests affected by municipal bond issues, but other strong and perhaps more quickly recognized reasons for its adoption will be a desire, on the one hand, to relieve State legislatures of detailed legislation for separate municipalities or classes of cities and towns, and, on the other, to see that the municipalities follow such general principles relating to municipal debts as may be formulated as the policy of the State. The net result will be to give most municipalities a freer hand in securing municipal loans than they now possess, while at the same time protecting them, their citizens and investors from extravagance in borrowing and from unwise loan conditions. Coincidently, safeguards would be established against the expenditure of money for ill-advised purposes and untried machinery and methods through the ignorance and inexperience of our ever-changing municipal officials.

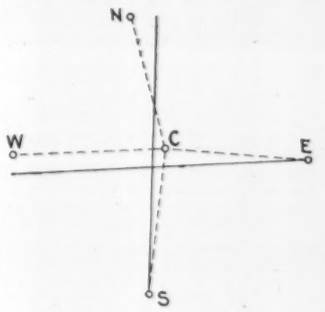
Whether or not central or State administrative control of bond issues is ever adopted in this country, municipal officials ought to address themselves to the problem of adjusting the life of their bonds to the life of the corresponding works. Most of the problems involved in such adjustments will come, in one way or another, to the engineer; and since he best understands the subject it will be his duty to do no little educational work to bring municipal governing bodies and the public to realize and to act upon the principle above enunciated that within reasonable limits the life of municipal bonds should be limited to that of the improvements for which they are issued.

LETTERS TO THE EDITOR

Relocating a Lost Section Corner.

Sir: Referring to the problem in land surveying where it is desired to relocate a lost section corner from the four adjacent ones, I have read with interest the solutions offered by Messrs. Smith and Llano in your issue of Oct. 12, but I must say that I doubt the soundness of their reasoning. Both gentlemen have assumed that the matter is purely a problem in mathematics, while as a matter of fact it is a question in surveying.

Both of your correspondents locate the corner in the northeast quadrant formed by the random lines run by Mr. Anderson. Now, as a matter of fact, the recorded distances shown on Mr. Anderson's sketch give at least four possible positions for the lost corner, depending upon which set of distances are used in the relocation; in other words, the government distances, as recorded, are inconsistent. If, for instance, we were to locate the



corner from W and N, instead of from S and E, it would fall in the southwest quadrant of the figure and about 600 ft. distant from the position assigned by Messrs. Smith and Llano. There are of course other combinations, but this is cited merely as an instance.

While I am not a professional land surveyor, it seems to me that the proper way to reset the corner would be to secure the bearings and distances of the lines from S to C and from C to E from the records of the county surveyor's office, and, after making allowance for changes in annual variation, begin at S, run in a northerly direction until a point has been reached where the measured distance equals the recorded distance and establish a temporary corner; thence run easterly to E, and if you strike E you may assume that the corner just set is in its proper place, if not, go back and make the necessary correction.

Public land surveying is not an exact science, but consists of a set of arbitrary rules prescribed by the United States Land Office. Mr. Anderson will find much valuable information in Clevenger's "Government Surveying."

Panhandle.

Canadian, Tex., Oct. 16, 1905.

Mechanical Efficiency of Steam and Gas Engines.

Sir: I have just read your very able editorial of Aug. 3, last, reviewing the discussion of last February, in the German association, of the proper meaning of the term "mechanical efficiency" when applied to gas-engine work. Permit me to add a word to the discussion.

There are, as you say, many ways of looking at this question, and each will result in a different conclusion. If it be remembered, however, that we are discussing merely the meaning of words, and not questions of fact, the difficulty will be much simplified. The problem then reduces itself to one of mere convenience.

It must be recalled, in the first place, that there is no possibility of distinguishing satisfactorily, even in the simplest types of steam engine, between thermodynamic and mechanical action, in reporting a test. The indicator card does not report thermodynamic action only. Every rounding of a corner, every bit of back pressure, is a question of the mechanical perfection of the valves and passages, or of the purely kinematic perfection of the valve gear. Further than that, even commercial considerations are recorded by the indicator. The incompleteness of expansion is one of the prime determinants of thermodynamic efficiency within the cylinder, and of the form of the card; and yet the degree of its presence is not determined by thermodynamic considerations at all, for in that case it would always be made complete, but by the commercial advisability of building cylinders large

enough to permit complete expansion. Therefore, let all attempts to frame a definition of mechanical efficiency which shall exclude all thermodynamic effects, and include all mechanical ones, be abandoned at the start, as impossible of attainment.

This once done, there does not seem to me any problem arising in connection with gas engines which was not already with us with steam engines. Solution along the same lines seems also to me to be quite adequate. In steam engine testing, quite as a matter of convenience, we have for long lumped all fluid phenomena together and called them "indicated." If, in the case of some types of condensing engines, we omitted the air pump resistance, it was an obvious case of misleading inconsistency; the sooner the precedent is forgotten the better. On the other hand, all metallic resistances (including lubricating oil as a necessary adjunct to the use of metal) we lumped together as "engine friction." Why, then, is this plan not completely satisfactory for gas engines? This calls for the inclusion of all pumping resistances, whether of air, gas or water, whether done on the idle strokes of the four-stroke gas engines or in the separate cylinders of the two-stroke engines, as negative parts of the indicator card. This is by far the easiest and simplest plan. I have found nothing brought forward in the German discussion which proves that any other is better, or so good.

Yours very truly,

Sidney A. Reeve.

Worcester Polytechnic Institute, Worcester, Mass., Oct. 17, 1905.

Some Notes on the Development of Eye-Bar Manufacture: Correction.

Sir: It requires some pulling against inclination for me to enter into a paper controversy, but statements of engineering details appearing in your paper are apt to become part of the history of the subject, so when an article containing such misleading data as that on "Some Notes on the Development of Eye-Bar Manufacture" in your issue of Aug. 17 is published, it seems to be one's duty, even when such an old friend as Mr. Springer is responsible for the statements, to put the facts where the searcher after truth may have an equal chance to land right if he be diligent.

Having represented Col. S. M. Seymour, Chief Engineer, as Inspecting Engineer in charge of the manufacture of metal and fabrication of superstructure for the Point Pleasant bridge, my recollection of the details is fairly good, and it does not agree with Mr. Springer's statement, and reference to the drawings and my records shows that the viaduct and principal portion of the truss spans were of iron, steel being used in the "End Posts, Upper and Lower Chords, Main Ties and Pins" of the 416-ft. span only. The iron was all manufactured at the Union Iron Mills and billets for the steel were ordered from the Cambria Iron Co., at Johnstown, Pa., and, though my records are not clear on this point, I think a special grade of Bessemer steel that Cambria made, and which later became known about the mill and among Cambria's customers, as "Pan Handle Bessemer," was furnished. There was a great deal of trouble experienced at the Union Iron Mills because of the shipment of defective blooms from the steel works, and by reason of blooms for tension steel (eye-bars 70,000 to 78,000 lbs. per sq. in. maximum) being too high in carbon and blooms for compression steel (angles and plates 80,000 to 90,000 lbs. per sq. in. maximum) being too low in carbon, and toward the last the Spang Iron & Steel Co. furnished some open hearth plates, covered by a total of twelve tests, to permit the shop to complete the work so as to avoid delay in the erection.

Lest Mr. Becker's measure of approval of bars manufactured under the "Springer Patent" might be misunderstood, it seems proper to give some facts concerning his acceptance of bars of that make.

In 1883 the Keystone Bridge Co. included in its exhibit at the Exhibition of Railway Appliances at Chicago the fractured portions of twelve 4-in. x 1-in. bars of steel that had been manufactured under the Springer process, and had given ideal results. With this exhibit as an argument Mr. Gottlieb, at that time President of the Keystone Bridge Works, persuaded Mr. Becker to permit that company to furnish similar bars for a bridge over the Big Miami River at Dayton, O., which was owned jointly by the P., C. & St. L. and C., H. & D. Mr. Joseph Ramsey, Jr., at that time Chief Engineer of the C., H. & D., concurred in this.

However, before the bars were made, Mr. C. L. Strobel, then with the Keystone Bridge Co., had patented a modification of the Springer process, consisting of the use of two side bars instead of the continuous bar bent around the ends of the main bar. We had all been so misled by the results of the tests on the 4-in. bars and the management felt so sure the Strobel process would be equally efficacious, and of course cheaper, that this method was followed instead of the one for which permission had been given, and the work of forging delayed until the riveted members were practically finished and partly shipped.

When the tests were made, eleven out of the eighteen bars broke in the head or neck; one before the yield point and three just after the yield point was reached. Of the seven that broke in the body of the bar, five were 1-in. or less in thickness, one had been annealed and two had been heated to a cherry red and quenched in fish oil.

The breaks showed plainly, as indeed examination of the forged heads did, that the side bars failed to weld to the main bar and everybody interested seemed satisfied that the process was not a success for the steel bars. As the Springer process involved the same necessity for welding two surfaces at right angles to the stroke of the hammer and depending upon pressure from the sides of the die as metal was forced into it, no attempt was made to see what would result from that method of manufacture.

The rejected bars lay in the stock yard for several years and finally the welded (?) heads were sheared off, new heads formed by upsetting, and bars used in some of the Keystone Bridge Co.'s later contracts. It is quite certain that the Keystone Bridge Co. never made another attempt to manufacture bars of steel under either of these patents, nor is it at all likely that anyone else ever did.

Iron bars of 1-in. greater width were then rolled for the Dayton bridge and an attempt made to manufacture them under the Strobel patent, but, after breaking 23 bars with failures in 20 that were, if anything worse than those obtained in the steel, that process was abandoned. The use of a wider bar with, of course, a larger head, resulted in fouling at floorbeams and top chords. Holes were first bored so as to be concentric with ends of head and eight bars so bored broke in the head when tested. Holes were then shifted in the balloon shaped heads until there was not less than 50% more metal through forward quarters of head than in net section of bar. Two bars so made broke in the body of bar and three in the necks near ends of piling pieces. The heads of ten bars then had a piece planed off to clear the riveted members and of these six broke in the head, three in the neck and one in body of bar.

Bars were then forged with the Springer piling, and of six tested three broke in the head, but after satisfactory elongation and under loads greater than was specified so that bars were accepted and are still in service. These bars also had the balloon shaped heads with cuts to give necessary clearance.

I think we always had satisfactory results in testing iron eye bars made under the Springer patents though their cost limited their use, but it gives a wrong impression to intimate that Mr. Becker approved this method for the making of steel bars.

Yours truly,

C. P. Buchanan,
Asst. Engr. of Bridges,
Pennsylvania Lines West of Pittsburg.

Pittsburg, Pa., Aug. 22, 1905.

Sir: The statement of Mr. Buchanan in reference to the material for Point Pleasant Bridge does not agree with my records. He states that "billets for steel were ordered from the Cambria Iron Co., Johnstown, Pa.," but that, while his records are not clear on this point, he thinks a special grade of Bessemer steel was furnished for eye-bars.

You will note the test sheet (Table I.) for six eye-bars made for the Point Pleasant Bridge reads that they were made of open hearth steel. This is a true record, and was prepared by Mr. C. L. Strobel. It seems to be convincing proof that Mr. Buchanan's records on Point Pleasant Bridge materials are not reliable. So much for Point Pleasant Bridge.

Mr. Buchanan says that it seems proper to give some facts concerning Mr. Becker's acceptance of bars made under Springer's patent. I send a copy of the Springer's patent No. 270-143, dated Jan. 2, 1883; application was filed September 13th, 1882. I made up from odd iron bars in stock of different sizes, a number of bars as per my invention and tested them, finding them satisfactory. I applied for a patent. I showed the test and mode of making to Mr. A. Gottlieb, then President of the Keystone Bridge Co. He approved of the plan and we stopped top piling and made all of the iron bars for all bridges, large and small, on the Springer patent plan.

After my patent was granted (please note my patent was granted Jan. 2, 1883), on Jan. 29, 1883, Mr. Chas. L. Strobel made application for a patent eye-bar. I send also a copy of the Strobel patent. Please note that both patents were handled by the same attorney, Geo. H. Christy, of Pittsburg, Pa. You will note that Strobel's specifications and claims are the same as mine.

Mr. Buchanan says that before the bars for the Dayton Bridge were made C. L. Strobel had patented a modification of the Springer process. He should have said, "Strobel re-patented the Springer process." He goes on to say: "We had all been so misled by the results of tests on the 4-in. bars and the management felt so sure that the Strobel process would be equally efficient and of course cheaper that this method was followed." I want to say here, without any fear of contradiction, no 4-in. Bessemer steel bars on Springer's patent were made for the Exhibition of Railway Appliances at Chicago, or for any other purpose. The Bessemer bars made for the Keystone Bridge Company's exhibit were 5-in. bars and gave satisfactory results as you will find by test sheets enclosed marked Table II.

In reference to cost, Mr. Buchanan had no record of the cost of any eye-bars, either iron or steel, made in the Keystone Bridge Co.'s forge at that time or at any other time. Mr. Gottlieb wanted the bars of the Dayton Bridge made under the Springer patent. Mr. Strobel, having charge of the drawing room, ordered the material for his plan.

Another point I want to call Mr. Buchanan's attention to is, he had no knowledge when he commenced to test and break the 18 bars in the head and neck, how the bars were made. He was under the impression they were made by Springer's process, as was agreed to by Mr. Becker and Mr. Gottlieb. After breaking so many he came to me about it. I then explained to him that the bars he had tested were not made by the Springer process but by a patent Strobel had taken out.

TABLE I.—RESULTS OF TESTS OF EYE-BARS FOR POINT PLEASANT BRIDGE.

(The bars described below are the first open hearth steel eye-bars made in the United States and were made in the machine and annealed in the machine shown in the article on the manufacture of eye-bars published in Engineering News, Aug. 17, 1905, these machines being designed by J. H. Springer.)

No. of Specimen		3	4	5	6	7
Specimen	Size, ins.	5 x 31/32	5 x 31/32	5 x 31/32	5 x 31/32	5 x 31/32
	Area, sq. in.	4.844	4.844	4.844	4.844	4.844
Fractured Sections.	Size, ins.	3-15/16 x 11/16	4 x 3/4	4-1/8 x 25/32	4-3/16 x 3/4	3-15/16 x 11/16
	Area, sq. ins.	2.707	3.000	3.223	3.141	2.707
	Per cent. of reduction	44.1	38.1	33.5	35.2	44.1
Elastic Limit.	On specimen, lbs.	202.800	201.500	211.900	214.500	213.200
	Lbs. per sq. in.	41.870	41.600	43.750	44.280	44.010
Ultimate Strength.	On specimen, lbs.	352.800	353.600	361.400	364.000	358.800
	Lbs. per sq. in	72.720	73.000	74.610	75.140	74.070
Elongation in 18 ft., ft.		1.542	1.614	1.687	1.698	1.750
Per cent.		11.9	12.4	13.0	13.1	13.5
Distance of point of fracture from back of pin hole, ins		3' 8-5/8"	3' 6-3/4"	7' 3-1/8"	1' 10"	7' 1-1/2"

NOTE.—These bars were made for the Ohio River Bridge at Point Pleasant, Ohio Central Ry., now in course of construction at the works of Keystone Bridge Co. They are of open-hearth steel of .30% carbon and were made by upsetting and die forging. The bars were annealed after manufacture, and were tested in the company's testing machine. Data taken from little book.

TABLE II.—TESTS OF BESSEMER STEEL EYE-BARS MADE BY SPRINGER'S PATENT PROCESS.

(These bars are of low Bessemer steel of 10% carbon. Made by welding piling pieces to the original bar. J. H. Springer's patent and die forging under the steam hammer. They were not annealed.)

No. of Specimen		12	13	14
Specimen	Size, ins.	5 x 1	5 x 1	5 x 1
	Area, sq. ins.	5.000	5.000	5.000
Fractured Section.	Size, ins.	4-1/8 x 5/8	3-13/16 x 11/16	3-15/16 x 3/4
	Area, sq. in	2.578	2.621	2.953
	Per cent of reduction	48.4	47.6	40.9
Elastic Limit.	Lbs. on specimens	179.400	178.100	175.500
	Lbs. per sq. in.	35.880	35.620	35.100
Ultimate Strength.	On specimens	286.000	289.900	291.200
	Lbs. per sq. in	57.200	57.980	58.240
Elongation	In 8'	1.333	1.542	1.738
	Per cent	16.7	19.3	21.7
Distance of point of fracture from back of pin hole, ins.		1' 3-1/2"	2' 7-3/4"	2' 4-3/4"

TABLE III.—Tests of Steel Eye-Bars for Blair Bridge.

		No. 1.	No. 2.
No. of specimen			
Specimen	Size, ins.	6-7/16 x 31/32	6-7/16 x 31/32
	Area, sq. ins	6.236	6.236
Fractured Sections.	Size, ins.	5-1/16 x 11/16	5-1/16 x 3/4
	Area, sq. in.	3.480	3.797
	Per ct. of reduction	44.2	39.1
Elastic Limit	On specimen lbs.	249.600	254.800
	Lbs. per sq. in.	40.000	40.800
Ultimate Strength	On specimen, lbs.	246.400	431.600
	Lbs. per sq. in.	68.370	69.220
Elongation	In 20 ft.	2.71	2.71
	Per cent.	13.5	13.5
Distance of point of fracture from back of pin hole, ins.		4' 5/8"	3' 8"

Note.—Bars Number 1 and 2. These bars made for the Missouri River Bridge at Blairs Crossing, Neb., now in course of construction at the works of the Keystone Bridge Co. These bars are open hearth steel of .24% carbon and were made by upsetting and die forging. They were annealed after manufacture and tested in company testing machine April 18 and 26, 1883, in presence of Chief Engineer George Morison and Inspector G. Henning.

He reported the results to Mr. Becker and the next day Mr. Becker came to the office and raised objection with Mr. Gottlieb about not making the bars as agreed to, namely, by the Springer process. The bars were then made up on the Springer process and are in the bridge to-day. This was over 24 years ago. I can furnish affidavits from the hammer man that made the bars and the foreman of the testing room who bored them and tested them that my statements are correct.

Mr. Buchanan closes by saying that he thinks they always had satisfactory results in testing iron eye-bars made under the Springer patents, although the cost eliminated their use. I desire to say that every iron eye-bar, large and small, made in the works of the Keystone Bridge Co. during my time as Superintendent was made under the Springer process. Bessemer steel was not acceptable to engineers of bridges for bridge members.

Yours truly, Joseph H. Springer, Sr.

Galt House, Louisville, Ky., Oct. 10, 1905.

(The patent specifications sent by Mr. Springer bear out his statement as to dates of application and allowance. The tables of tests referred to by him are given herewith.—Ed.)

Notes and Queries.

R. R. L. writes:

How can a reinforced concrete reservoir 15 ft. deep that is to be above ground and exposed to the cold be made watertight? Can vitrified sewer pipe be so joined that it will withstand the pressure due to a head of 40 ft. of water? What is a good method of constructing a bulkhead in a cement canal so that it will be watertight?

Regarding the query as to which is the right bank of a stream, Mr. F. Hodgman, of Climax, Mich., refers us to the following from the United States Manual of Surveying Instruction:

156. Proceeding down stream the bank on the left hand is termed the left bank and that on the right hand the right bank. These terms will be universally used to distinguish the two banks of a river or stream.

Mr. Geo. Jacob Davis, Jr., of Madison, Wis., also refers us to p. 227 of Raymond's Plane Surveying (edition of 1896), and p. 224 of Hodgman's Manual of Land Surveying (edition of 1902), where the right and left banks of a stream are defined in the same way.

C. C. W., Columbus, Ga., writes:

I would like to know what style rail is considered best for use on streets paved with asphalt, bitulithic or other monolithic pavements. What style construction is considered best in paving in and about the tracks? I notice in many places brick and stone are used next to the rail on streets paved with other material.

I would appreciate it if you would refer me to articles in Engineering News which treat on this subject.

Either T-rails or girder rails can be used successfully on such streets; but there is not the same necessity of a deep rail as where block paving is used. For paving alongside the rail, both vitrified brick, specially shaped to leave a flange-way and stone blocks are in use, the latter having the preference where the street is subject to very heavy traffic. By using alternate headers and stretchers, a toothed junction is made with the asphalt and the tendency toward wearing a groove or rut along the edge of the asphalt is reduced. See Engineering News, January-June, 1904, p. 96; January-June, 1902, pp. 188, 232; July-December, 1901, p. 495. Also Proceedings of the American Society of Municipal Improvements.

CONCRETE REVETMENT FOR A 200-FOOT CLIFF, NIAGARA RIVER GORGE, NIAGARA FALLS, N. Y.

The accompanying illustrations show a concrete revetment now being built for the rock cliff of the Niagara Gorge at the works of the Niagara Falls Hydraulic Power & Manufacturing Co., Niagara Falls, N. Y. This company was the first to develop power from Niagara Falls; its power house is located at the foot of the cliff at a point just north of the American end of the steel arch highway bridge, the wheels taking water from vertical steel penstocks, as shown by the view Fig. 1. In constructing these penstocks and the power house the talus protecting the face of the shale cliff was removed; as the shale rapidly disintegrates under the action of the elements, it was foreseen that, ultimately, the cliff must be protected or else the eating away of the shale face would leave the overlying limestone projecting like a shelf, which in time would break off in mass and damage the power plant and penstocks. The revetment illustrated is the protective work decided upon by Mr. John L. Harper, the chief engineer of the power company.

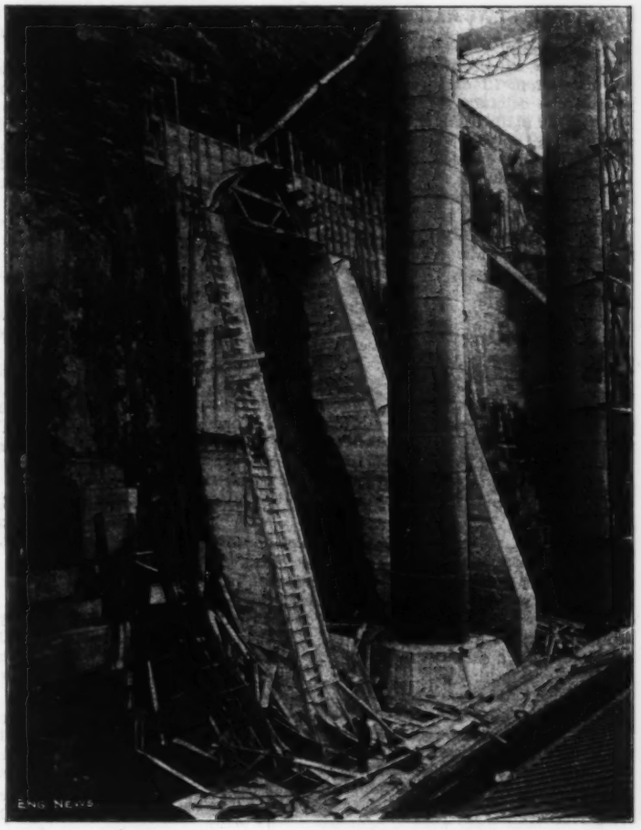


FIG. 1. VIEW SHOWING REVETTING OF CLIFF OF THE NIAGARA RIVER GORGE WITH CONCRETE.

As shown by Fig. 2, a concrete facing or revetment is being put into the cliff face. The facing or revetment drops to the level of the tail water and rises 150 ft. above the eaves of the power house, making its height about 200 ft., while its width along the cliff is 200 ft. At no point is it less than 2 ft. thick, while in places it has a thickness of 12 ft. The bank had previously been faced up to the shale with concrete, and at that time the possibility or advisability of extending it had not been considered. It was therefore deemed advisable to construct three pilasters to give a more substantial support to the top and heavier parts of the facing wall. Each of these pilasters is 5 ft. wide and 80 ft. high.

Between two of the pilasters there exists a natural grotto in which a noted spring is located. This grotto has been protected by an arch, Fig. 1, without in any manner detracting from the strength and usefulness of the wall. There is quite a little seepage from the bank at this point, but a series of experiments made by Mr. Harper showed that the water never attained a temperature lower than 39° F. in the most severe weather conditions, which would indicate no danger of freezing behind the facing wall. Furthermore, its removal is abundantly provided for by means of weepers.

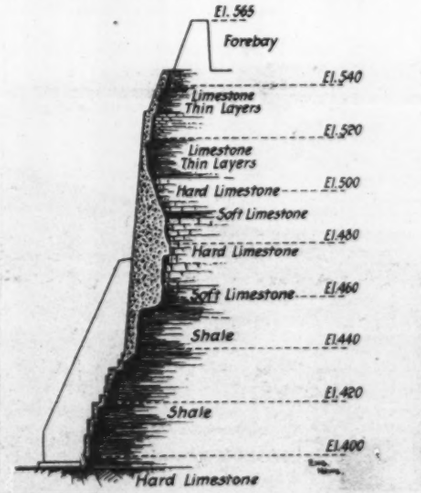


Fig. 2. Vertical Section of Concrete Revetment, Niagara River Gorge.

The concrete used in the construction of the wall is a 1-3-5 mixture filled with clean rubble. All the sand and stone used in the wall was dumped on the east side of railway tracks 300 ft. back from the edge of the bank, from which point it was carried by means of an aerial cableway to the concrete mixer at the edge of the cliff. The mixture was dumped into chutes that carried it to a point of use without causing a separation of the concrete. The mass slid as a unit and did not roll, the chutes being steep, smooth and small. The wall contains about 7,000 cu. yds. of concrete, of which amount from 80 to 90 cu. yds. were placed daily. The illustrations indicate the method of construction clearly. For these and for the information from which this account of the work has been prepared, we are indebted to Mr. Orrin E. Dunlap, of Niagara Falls, N. Y.

TANK LOCOMOTIVES of the 2—6—4 type are being built for the Panama Ry., specially for the construction trains of the canal works, and 24 of these engines have already been completed. They have side tanks above the running-board and a combined tank and coal bunker behind the cab. The principal dimensions are as follows:

Gage of track	5 ft. 0 ins.
Driving wheels	4 " 6 "
Leading truck wheels	2 " 6 "
Trailing truck wheels	2 " 4 "
Wheelbase, driving	13 " 2 "
Wheelbase, total	32 " 8 "
Weight on drivers	124,000 lbs.
Weight, total	183,500 lbs.
Cylinders	19 x 26 ins.
Slide valves, balanced; travel	5½ ins.
Boiler, diameter	5 ft. 2 ins.
Boiler pressure	180 lbs.
Firebox	7 ft. 6 ins. x 3 ft. 6 ins.
Tubes, 220; diameter	2 ins.
Tubes, length	12 ft. 0 ins.
Heating surface; tubes	1,373 sq. ft.
Heating surface; total	1,498 sq. ft.
Grate area	26 sq. ft.
Capacity of tanks	3,700 gallons
Capacity of coal bunker	5 tons
Fuel	Bituminous coal

AN OLD WOOD STAVE WATER INTAKE AT QUINCY, ILL.

By Edward Prince,* M. Am. Soc. C. E.

The water supply of Quincy, Ill., is taken from the Mississippi River through a 30-in. kiln-dried yellow pine conduit, 1,500 ft. long, running to a point in the main channel of the river. The pipe was of 6-in. staves, 16 ft. long and 3 ins. thick before dressing, dressed on the inside to an internal diameter of 30 ins. (see Fig. 1). In the center of the full length of the side of each stave was cut a groove ½-in. wide and deep enough to receive a tongue of thoroughly seasoned pine, scant ½-in. thick and ⅞-in. wide. These tongues, first white leaded, were put in the grooves as the conduit was constructed, and entirely filled the grooves after the pipe was in the water. The staves broke joint every 4 ft., and being 16 ft. long, all the joints formed at that even distance.

Fig. 1. Details of Wood Stave Intake Pipe, Quincy, Ill.

(The clamp was used while bending the ends of the hoops over the ring.)

The end of each stave was cut to receive an iron plate 5 × 7 × 3-16 ins., which entered the end of each stave 3½ ins. On the outside of each butt joint was nailed a plate 3-16 × 6 × 8 ins. (with holes punched in each corner for heavy galvanized nails), covering the butt joints each way 4 ins. The wrought nails were clinched on the inside of the conduit. These outside butt plates are embraced by the hoops. All plates were thoroughly painted as put in place. Hoops of ½-in. iron, 10 ft. long, encircle the pipe and these plates every 4 ft., and are put on with a removable clamp, the ends of clamp having two 1-in. draw bolts. The hoops are bent back with a hammer over a solid ½-in. iron link. A side rod of ⅝-in. round iron runs continuously on each side of the pipe, being well secured with galvanized wire to every hoop and being provided with turnbuckles.

The first section of completed pipe was 540 ft. long, and was successfully launched into Quincy Bay on iron railroad bars from the ways on which it was put together, as shown by the view, Fig. 2. The second section was of the same length, and the third 420 ft. in length. The three sections were towed out of the bay down to the Mississippi River, and the third section, secured to the first by a half sleeve of boiler iron, 4 ft. long, flanged and bolted with ⅞-in. bolts; also by a ⅞-in. iron rod, fastened to lugs on each section, and also by a draw rod connecting the side rods on the conduit. These two sections, 960 ft. in all, were laid in one piece. The joint between the middle and last section was made under water by diver, using a boiler iron flanged half sleeve, 4 ft. long, with ⅞-in. bolts on each side, well drawn up, without other fastening.

The crib is 52 ft. long, 16 ft. wide and 8 ft. high, with a V-shaped ice breaker on its upper end. The end of the conduit projects some 4 ft. into a chamber on the upper end of the crib and is bolted to a heavy oak floor. There is an oaken deck above the chamber, some 4 ft. high, closed at the upper end 4 ft. beyond the end of the conduit. The crib lies in 12 ft. of water at low water mark, out of reach of passing boats. The conduit lies from 12 to 20 ft. below low water. Eight piles were driven alongside the pipe and crib to resist the transverse thrust of the current. Two of the piles are bolted to the conduit by a bent arm of 1¼-in. iron, passing over the pipe and bolted to the piles, which were afterwards sawed off by the diver, about 4 ft. from the bottom. The other piles were sawed partly in two before driving and broken off by a pile driver afterwards about 3 or 4 ft. from the bottom of the river. The last section of conduit has a slight curve in it, due to cross currents, wind and ice while it was being laid.

The crib was heavily ballasted with riprap, and the conduit is held in place at the bottom of the river by stone ballast, saddle-bagged to the hoops by galvanized wire.

Two steamboats, a pile driver, one dredge and ten barges of stone, carrying about 70 cu. yds. each, lowered the pipe and made everything secure in one day, without any accident, although some ice was running in the river at the time. The total cost of this entire construction was less than $10,000.

The pipe was designed, constructed and laid by the writer, one of the owners of the works, in November, 1887, and examinations recently have shown the pipe in perfect condition.

The entirely novel construction, especially in the use of iron hoops without any sort of lugs, screws, nuts, etc., has demonstrated the efficiency of an iron hoop slightly imbedded in the wood stave by a removable iron clamp and bent over a common iron ring. The mortise inside of the stave does not involve any loss of the wood of the stave, as a rigid tenon would, and the small tongue of wood is quite inexpensive and secures a tight joint.

The test of time has demonstrated the perfection of this method of bonding the wood pipe and the simplicity and cheapness of the method over all others must be apparent to every one.

*Consulting Engineer, Quincy, Ill.

A LOCOMOTIVE TESTING LABORATORY is to be built in Germany at the Grunewald Works, on similar lines to that at the St. Louis Exposition. It is to be in charge of the well-known locomotive designer, Prof. Von Borries.

FIG. 2. LAUNCH OF WOOD STAVE INTAKE AT QUINCY, ILL., IN 1887.

REPORT OF BOARD OF INVESTIGATING ENGINEERS ON THE PHILADELPHIA FILTRATION AND BOULEVARD CONTRACTS.

The report of Major Cassius E. G[illespie], U. S. Engineer Corps, and Mr. John D. Ma[cArthur], M. Am. Soc. C. E., appointed a Board of Investigating Engineers by Mayor Weaver, of Philadelphia, Pa., in July of this year, to investigate and report upon all matters relating to the work on the city's new filtration plant and boulevard system, has been made public. The full report as published in the Philadelphia "Public Ledger" of [Oct. 30], is reprinted here, retaining the headings used in the newspaper from which we quote:

Board of Investigating Engineers,
Room 712, City Hall,
Philadelphia, Oct. [30], 1905.

Hon. John Weaver, Mayor, City of Philadelphia, City Hall:

Sir—In compliance with your letter of July [—], 1905, requesting us to make an examination of the filtration system already built or in course of construction for the city of Philadelphia, and the accounts and contracts relating to the same, and the methods of making such contracts, and to report to you as to all matters relating thereto that, in our opinion, it would be of benefit to the public service that you should know, and second, to make a similar examination and report on the Northeast and Southern Boulevards of the city, now under process of construction, we have the honor to submit the following report:

This covers all the above subjects, except the physical condition of the Torresdale conduit, which will be made the subject of a report of a board, consisting of Mr. William Barclay Parsons and ourselves, at such future time as the conduit may be pumped out and Mr. Parsons may be able to make the inspection with us.

We have made physical examinations of the various works and have given a great deal of time to the office records and other sources of information as to the letting of the contracts and their execution.

Omitting from consideration all small contracts—say under $30,000—we find that for the filtration work and the two boulevards as constructed up to date, the city has paid or pledged $18,761,541.23.

First-class work under the specifications should not have cost over $12,430,000, which includes an allowance of 20%, or $2,075,208, for legitimate contractors' profits.

$18,000,000 FOR WORK COSTING $10,000,000.

The difference is $6,330,000. In other words, $18,760,000 in round numbers has been paid for work costing the contractors $10,356,000.

Of the $6,330,000 excessive cost, there has gone to the contractors who worked under the name of D. J. McNichol $5,065,122.51; similarly to Ryan & Kelley, $543,890.21, and to Vare Brothers, $89,128.50.

Of the above $18,761,541.23, there remains unpaid about $568,000 to McNichol, and $75,000 to Ryan & Kelley.

Some of these contracts are incomplete; the estimated cost of completion of the existing filtration contracts at contract prices is about $1,685,000. A fair price, allowing 20% profit, would be $1,218,000. The difference, $467,000, the city will lose if these contracts are completed.

CITY LOSES $273,000 IN BOULEVARDS.

The price paid for the three-quarters of a mile of Northeast Boulevard already constructed is $552,348.45, on which there was a loss to the city of $273,217.

There are nine and one-half miles more of it laid out on the maps. If completed at contract prices, the additional cost to the city will be about $6,500,000, and the additional loss at least $2,250,000. On the Southern Boulevard, amount paid to date is $286,389, on which the loss on the one and a quarter miles built has been $89,128.

To complete at contract prices would cost $350,516, and the additional loss would be about $83,555.

In other words, the total cost of both boulevards as planned at contract prices would have been $7,636,000, and the total loss to the city $2,750,000.

WORK CALLED SECOND CLASS.

The above $6,330,000 is the difference between what has been paid and what should have been paid for first-class work, but much of the work done by Ryan & Kelley and D. J. McNichol is not first-class. The parts which show prominently to the public are fairly well done; the parts that can be examined with a little trouble are distinctly second-class, and not up to the specifications. We, of course, do not know the condition of such portions as cannot be seen without tearing up the work; but wherever we have dug into it, we find it second-class or worse.

The Southern Boulevard work, so far as can be seen, is good work. As yet only the rough work of filling has been done.

On the Northeast Boulevard, the crushed rock used in surfacing is excellent material, but the foundation rockwork we find to be very poor. A friable micaceous

rock was used, which will disintegrate under travel and make sink in the crushed rock surface. These will require constant mending, making it a patchwork roadway. It should be torn out and the foundation replaced with proper material.

BELMONT FILTERS BADLY CRACKED.

The concrete work of the filtration contracts appears to be of fairly good materials, rather poorly mixed and not carefully placed. Plastering, washing and other expedients for covering cheap work were generally permitted. The embankment work was generally poor, manifesting itself in cracks and settlement.

While the specifications were unusually exacting, we have found few places where the work could have been more cheaply constructed without jeopardizing its stability, or its inferiority being apparent to the public. Indeed, three of the Belmont filters are badly cracked and will doubtless go to pieces many years before first-class work would have given away, and a large terra cotta drain at Roxborough is practically useless already. This pipe is twelve feet under ground.

Of the filtering materials furnished by McNichol and now subject to inspection, we find a large part of the sand to be a very inferior material, not up to the specifications in chemical quality or effective size and containing too much fine material. In addition, it is of a very dirty color and contains too much coarse material. These last two items were not specified, but should have been.

This poor sand is from the Delaware River. The rest of the sand is bank sand and generally of much better quality. In all the filters that have been completed the river sand is covered up out of sight by a layer of the much better looking bank sand. In addition to whatever effort to hide bad materials that may be involved in this, it is bad arrangement. The qualities of sand in a filter should be uniform from top to bottom. The gravel is decidedly dirty.

While the aggregate difference between the value and cost of what was furnished and what was called for by the specifications was a large amount, we cannot estimate it without unduly tearing up the work. The greater part of the wrong done the city lay in the excessive profits provided by the contracts.

UNFAIR COMPETITION.

One of the means by which these excessive profits were made possible was by not permitting fair competition.

The advertising for bids was wholly inadequate; scarcely more than a pretense. For a typical example, take contract No. 16 for Belmont filters and reservoir, costing about $2,000,000. This was advertised by three insertions each in the "Telegraph," "Inquirer" and "Gazette," all local papers, and notice first appearing 24 days before the letting. This was wholly inadequate. The work to be done was very complicated and very difficult to estimate. The specifications were voluminous and vague, covering 112 printed pages. The drawings covered no less than 43 large sheets of close complicated work, each sheet over 10 sq. ft. in area.

It was quite impracticable in the time allowed for even a local contractor, noticing the advertisement the first day it was published, to make up his estimate of quantities alone, to say nothing of the many other things a bidder must do, before he can submit an intelligent bid. There was no advertising for this large contract in any of the engineering journals, where contractors look for such notices.

It is also customary in engineer offices to keep lists of contractors to whom specification or invitations to bid are sent, without asking. Nothing of this kind was done. This is a fair sample of the notice given for the large contracts for the filtration works.

PRIVATE SURVEY MADE.

The history of the boulevard advertising is as follows:

A survey was made and the Northeast Boulevard laid out by private parties before the city had anything to do with it. Councils passed the ordinance to fit this survey.

The work was afterward laid out by the Bureau of Surveys in accordance with the ordinance. This brought it sufficiently close to the map previously made by private parties to make no change in the list of properties benefited or the list of lots from which the city must buy, if it completes the work.

The specifications were very voluminous, and include eighty-two different items, the most of which required special and painstaking calculation to cover the many details. These specifications were available to bidders ten days. The bids were opened March 25, 1903, three days before the ordinance authorizing the advertisement for bids was approved. Eighteen persons had asked for specifications. McNichol was not among them, nor is he on record as having taken out specifications for the Southern Boulevard, yet he bid on both. Only two bids were received, and there is a remarkable unanimity in the prices.

The advertising was as follows, the first appearance being 14 days ahead of the ordinance authorizing the advertisement:

The "Item," March 14, 17 and 24, 1903.
The "Inquirer," March 16, 21 and 25, 1903.
"German Gazette," March 18, 19 and 23, 1903.
"Sunday World," March 15, 1903.
"Sunday Despatch," March 15, 1903.
"Sunday Transcript," March 22, 1903.

Under these circumstances real competition was out of the question.

On the Southern Boulevard the ordinance authorizing the work was approved June 27, 1904, and the bids were opened July 28, 1904.

The advertisements appeared as follows:

The "Inquirer," July 19, 23 and 28, 1904.
The "Item," July 19, 22 and 26, 1904.
The "Telegraph," July 21, 25 and 28, 1904.
The "German Demokrat," July 20, 23 and 27, 1904.
"Sunday Despatch," July 24, 1904.

This advertising does not even comply with the law, which requires at least ten days for the smallest contract. The dates of advertisements and opening bids are fixed by the Director of Public Works.

ESTIMATES GUARDED AS SECRET.

A careful analysis of all the filtration advertising indicates that everything possible was done to avoid any real publicity without letting that fact appear too prominently in the records. Had the bids been itemized, as they should have been, bidders could have made intelligent bids upon the different classes of work at unit prices, and the period allowed would not have been so unreasonably small. But this was not permitted, except for pipe lines. Lump sum bids were required, which demanded that the bidder make careful detailed estimates of quantities.

The bureau's preliminary estimates, instead of being freely furnished to bidders, were rigorously guarded secrets, so far as the general bidder was concerned, except that they were furnished in the specifications for filtering materials, where they were very little needed.

The specifications in many particulars were unfair to bidders and gave excessive and unnecessary power to the city officials. For example, in the above contract for Belmont, one paragraph gives the engineer power in his discretion to require the contractor to do more than $100,000 worth of extra work, for which he would receive no pay whatever. It was provided that if the earth foundations when uncovered were not "satisfactory" to the engineer, he could require the contractor to excavate to any depth he pleased and fill it up with concrete without expense to the city.

In many cases the specifications gave the Director of Public Works authority to change the plans and specifications to an unlimited extent and to fix the price of the work as changed. In one case this power was exercised to make not less than 62 material changes in the plans. No less than 89 supplementary sheets of drawings were made after the contract was let. The contractor, George C. Dietrich, went into bankruptcy. This case will be discussed at length further on.

In the specifications for the conduit, a rock tunnel from end to end, the contractor was required to "provide a shield and excavate by the pneumatic or other improved method when or where, in the judgment of the engineer, it is necessary for the safety or better progress of the work," and he must "work in the tunnel and shafts in compressed air whenever, in the opinion of the engineer, the conditions are such as to require it." These provisions put it in the power of the engineer to add greatly to the contractor's expense. That they were intended to be taken seriously is shown by the elaborate compressed air regulations accompanying them. In the actual work nothing of the kind was used.

In the specifications for filter sand and gravel there was inserted a paragraph which gave the Director so much authority to make changes in the sizes that it could easily have been used to double the cost of the contractor, without any increase in his prices.

HOW UNWELCOME CONTRACTORS WERE BARRED.

In short, the specifications were so drawn that the engineer could harass an unwelcome contractor to an almost unlimited extent, without the contractor being able to prevent it or secure legal redress. We estimate that the engineer acting within his rights under the specifications could add 25% to the cost of the work to the contractor or, on the other hand, lessen it 25%.

Under these circumstances, it is not to be expected that much real competition would exist; and very little do we find.

For the above two million job the competition was limited to only two firms, Ryan & Kelley and D. J. McNichol. Of the four other contracts that were let for filters, three of them brought out only two bids each—the same Ryan & Kelley and D. J. McNichol. They were:

No. 10—Lower Roxborough	$557,000.00
No. 12—Upper Roxborough	250,000.00
No. 25—Torresdale	5,000,000.00

The same is true of all three contracts let for sand and gravel to fill the filters. They were:

No. 24—Roxborough	$280,000.00
No. 49—Belmont	365,000.00
No. 50—Torresdale	1,000,000.00

On the contract for Roxborough, D. J. McNichol was the only bidder.

ONLY TWO BIDDERS ON $9,000,000 OF WORK.

Here we have contracts let for an aggregate of over $9,400,000, with the competition limited to one pair of bidders. Some of the facts that indicate that even these must have been known to the officials responsible to the collusive bids will be given further on.

The advertising for the Filtration Bureau was nearly all of the kind above described. An apparent exception is that for three openings in 1904, advertisements were inserted in two New York engineering papers, the longest interval being 14 days before the opening. For one opening, the advertisement appeared in the "Engineering News" only four days previous to the letting. Such advertising is merely a form.

In few cases was the period of advertising long enough to secure appropriate competition.

The specifications were generally very severe, very vague in some respects, very elaborate and involved, and altogether too much was left unnecessarily to the discretion of the engineer to make it safe for the general bidder to submit a bid at a reasonable price.

HADDOCK, HILL AND COSTELLO RESPONSIBLE.

The city officials directly responsible for these conditions were Directors Haddock and Costello and Chief Engineer Hill.

The system of combining short advertising and lump sum bids began with the advent of John W. Hill as resident consulting engineer. Just previous to that a large contract No. 7, for Lower Roxborough filters, had been advertised for itemized bids. Without any apparent reason these bids were all thrown out, and the work was readvertised as contract No. 10 under Mr. Hill and let at a lump sum for a higher price to D. J. McNichol.

A frequently used method of guiding contracts into the desired hands was to readvertise them, whenever others were the lowest bidders. The contract just mentioned was one of these. Another, No. 19, for pipe lines, was readvertised and given to McNichol at a price $40,000 higher than the lowest bid at the first letting, and he was not even the lowest bidder by $35,000 at the second letting.

On another occasion the contract (No. 24, for Roxborough filter materials) was given to him as the only bidder on the second letting, at a price higher than his own and $18,000 higher than the lowest bid on the first letting. On another occasion (No. 66, for pipe lines), McNichol bid $146,000 (evidently intended for $76,000). The lowest bid was $50,000. It was readvertised for no apparent reason and let at $56,000, McNichol's bid being $63,800.

McNICHOL'S THREE ILLEGAL CONTRACTS.

Still another method was, instead of stating in the specifications when the work must be completed, the bidder was required to set the time himself, and this governed the award whenever it would result in McNichol getting the contract. Six contracts (Nos. 10, 12, 14, 17, 19 and 54), aggregating $3,800,000, were thus given to McNichol when he was not the lowest bidder, but proposed to do the work in the shortest time.

In three of these contracts such action was wholly illegal, as the specifications for two of them (Nos. 10 and 17) contained no provision for such action, and the third (No 14) provided rather vaguely for "due consideration" being given the proposed time of completion—"other things being equal." Other things were not equal.

In later specifications this was changed by omitting the phrase "other things being equal" and permitting "due consideration" of the proposed time of completion to be given sufficient scope to control the letting.

$140,000 LOST TO THE CITY.

The aggregate loss to the city on the face of the bids for these six contracts was $140,000. Not one of them was done on time and not one of them was done within the longest time proposed by any bidder. In the largest of them (No. 14), the Torresdale Conduit, on which the loss to the city on the face of the bids was over $30,000, the time proposed by the lowest bidder provided for finishing the work about Oct. 1, 1902—only about six months later than McNichol's bid proposed.

At the time the award was made the work could not possibly have been expected to be put into use before October, 1903, and actually cannot be used for the purpose for which it was constructed before October, 1907. McNichol, instead of completing it within nine months after the notice to begin, did not finish till April 23, 1904, after two years and three months had elapsed.

CONTRACTS GIVEN TO McNICHOL ANYHOW.

We find that when all the above methods failed to furnish a pretext for giving the work to McNichol, it was given to him anyhow. This drastic process was only necessary on one occasion, but the contract (No. 9, for pipe lines) was a large one, amounting to over half a million dollars. The loss to the city on the face of the bids was $28,000, and that was after McNichol had been permitted to reduce his bid by about $8,000 a week after the letting. His original bid was informal, in that he had omitted to state in it any proposed time of completion at all. Nor is there the slightest pretext apparent on the bids or discoverable in the records of the bureau for arbitrarily giving McNichol this contract. Afterward the award was annulled by the courts.

The work then, instead of being given to the lowest bidder, Ryan & Kelley, who had brought the suit in court, was readvertised as a part of No. 17, the new

letting being two months after the first. Ryan & Kelley for some reason raised their bid $57,000 on the part of the work represented by No. 9, but on No. 17 as a whole were still $26,000 lower than McNichol. In spite of this, as stated above, the contract went to McNichol. Ryan & Kelley made no protest. One month later they were awarded a $2,000,000 contract for Belmont filters and finished it under peaceful conditions, the like of which did not obtain to other contractors who subsequently got contracts away from McNichol, as will be explained further on in this report.

Since that time Ryan & Kelley have bid on eight contracts on which McNichol was also a bidder. Previous to and including the Belmont filter contract they had similarly bid on seven. On the earlier ones their bids when compared varied quite materially; sometimes McNichol was the lower, sometimes Ryan & Kelley.

WAS THERE COLLUSION IN THE BIDS?

Since the Belmont contract, however, Ryan & Kelley are invariably just a little higher, under circumstances that make such uniformity quite remarkable. For instance, on No. 27, the Oak Lane Reservoir, McNichol bid $1,257,240; Ryan & Kelley less than 3% above that. The contract was let to R. A. Malone & Co. for $532,560, much less than one-half of McNichol's bids, and yet ample for the work. Mr. Malone kept the fact that he was to be a bidder secret until Ryan & Kelley's and McNichol's bids had been submitted. As Ryan & Kelley and McNichol were both experienced contractors, the uniformity in their excessively high bids could not have been accidental.

This one episode may not prove collusion between these two bidders, but it certainly should have prevented the chief engineer and the Director of Public Works subsequently awarding two enormous contracts for sand and gravel to D. J. McNichol when Ryan & Kelley's was the only other bid, and McNichol's price more than two and a half times those quoted by other bidders recently on precisely the same specifications.

When McNichol bid $1,476,730 for the Lardner's Point Pumping Station, worth about half that figure, Ryan & Kelley's went to a point just 3% higher. At a subsequent letting for a part of the work, when McNichol did not bid, they were awarded the contract as stated above, when theirs was not the lowest bid, time of completion considered, and they are now building for $330,000, something less than half of what they bid $1,537,200 for, when their bid was so near McNichol's.

The exact figures are about as follows. The complete station as constructed should cost about $14,000 less than the one above discussed. Ryan & Kelley are building half the present station, less $138,000 worth of conduits, etc. Therefore, at the prices for which they are building the present station, the whole establishment should cost about $752,000, and, therefore, their bid when they followed McNichol so closely was excessive by about $785,000. On No. 25, Ryan & Kelley's bid was less than 2% higher than McNichol's, which was nearly two million dollars above a fair price.

NO COMPETITION BETWEEN RYAN & KELLEY AND McNICHOL.

It is evident, therefore, that competition between Ryan & Kelley and McNichol was no competition at all, and this should have been apparent to Chief Engineer Hill, who was the responsible official that should have had cognizance of all these facts.

We have found many proofs and indications of collusion involving other bidders that must have been known to Mr. Hill, but, as our researches in this field are incomplete, it does not seem necessary to discuss them here. We have tabulated many important facts on this and analogous subjects, which tabulations when completed will be at the disposal of your attorneys.

Another provision of the specifications which must have intimidated many bidders was the threat of assessment of liquidated damages at rates of from $50 to $1,000 per day for each day over time. If a bidder received private information that this would not be enforced, he could ignore it; but no other bidder would dare propose to complete the work in a shorter time than he could actually expect to finish it.

The McNichol bids always proposed strikingly short periods for completion—much shorter than would ordinarily be required to do the work; and the proposed time was always exceeded by from 10 to 200%.

In the aggregate McNichol could have been assessed for liquidated damages for overtime about $532,000. He was actually assessed $3,255.

Three-fourths of this assessment was on the first filter contract, and must have made bidders on the later contracts think the assessment clause would be enforced.

HOW McNICHOL WAS PROTECTED.

A rather ingenious device in this connection was to delay the date of notice to McNichol to begin work. For instance, in the case of the conduit above mentioned, the work was to have been done in nine months after notice to begin was given. This notice was dated seven months after the letting and four months after the award. It had been previously sent and withdrawn at the contractor's behest for very trivial reasons. It was not sent finally till the contractor had let his sub-contracts and he and all his sub-contractors had gathered and installed their machinery and been actually at work on the ground over three months. Five of the nine working shafts had been sunk to bed rock and lined with steel. Three more reached bed rock a few days later.

On another large contract (No. 50) the notice to begin was delayed six months. It was originally given one month after the letting and then canceled. The contract was for filtering materials, and the reason given for the cancellation was that no filters were ready. If not, then the advertising of this contract was inexcusably short. The contract was for over a million dollars, and it was advertised for just fourteen days. The only bidders were Ryan & Kelley and D. J. McNichol. The prices were exorbitant.

On two other contracts (Nos. 19 and 24) the notice to begin was not given till three months after the award. One of these (No. 19) had been given to McNichol on his proposal to do the work in six months, against the lowest bidder's seven, the low bid being $36,000 less than McNichols. Six months had already been lost by readvertising this contract, McNichol not being the lowest bidder at the first letting. On the other (No. 24) a contract for $280,000, after an advertisement for twelve days in the "Demokrat," "Inquirer" and "Item," McNichol was the only bidder at exorbitant prices. More bids might have been received if six weeks' longer advertising had been given this contract.

McNICHOL RELEASED FROM ASSESSMENT.

These late dates of notice to begin work made the overtime for which liquidated damages could be assessed about $96,000 less than it would have otherwise have been. In this connection we note that not only was McNichol released from the assessment of liquidated damages, but even the expenses of supervision for the overtime was not charged against him. These amounted to $71,295.22, salaries actually paid by the city for inspection of his work after the contract time had expired.

These acts point to a deliberate plan to lessen the difficulty of releasing McNichol from the assessment of liquidated damages. This indication is strengthened by the following quotation from a letter sent by Chief Engineer Hill to Contractor McNichol under date of July 8, 1902, urging haste in completing contract No 24, "and in view of the fact that from the time of the award of the contract to the expiration of the time limit is nearly nine months to supply less than 13,000 cu. yds. of sand, it will be very difficult to find any reason why an extension should be granted."

We find that on at least one occasion Mr. Hill used the rate per day penalty applied to the difference in days between two proposed dates of completion to turn a contract into McNichol's hands, when he was not the lowest bidder. This was No. 54, for over half a million dollars. On the other hand, we find three cases (Nos. 10, 17 and 19) in which a similar action would have given the contract to some one else; but this method of comparison does not appear in the records as having been used for these contracts and they were given to McNichol. They aggregated nearly a million and a half, and the loss to the city on the face of the bids when compared by this plan was $65,000.

SOME SAMPLES OF PROFIT.

We find two other cases (Nos. 19 and 24—first opening of bids) where this method of comparing bids would have given the contract to others, at a saving over McNichol's bid of $70,000. They were readvertised instead, and finally given to McNichol. In one of these cases (No. 24) the work could have been done under the first bids for $28,000 less than McNichol finally completed it, and the bidder's proposed time would have completed it three months before McNichol was notified to begin work and a year before he actually completed it.

On another occasion (No. 68) this allowance for difference in proposed date of completion would not have given the contract to Ryan & Kelley, but neglecting the proposed time of completion, they were the lowest bidders and they got the contract. Director Costello recommended that this contract be given to Dietrich. Chief Hill recommended it be given to Ryan & Kelley. In making the comparison between the bids, Mr. Hill did not use the figures specifically prescribed in the specifications for that purpose, but used partial figures favoring Ryan & Kelley. It was for $330,000, as mentioned above. McNichol was not a bidder under his own name for this contract.

CONTRACTS JUGGLED FOR FAVORITE CONTRACTORS.

These facts prove conclusively to our minds that the time of completion and liquidated damage matters were used for the distinct purpose of juggling the contracts into the desired parties' hands.

Whether or not they were put into the specifications for this purpose we, of course, do not know. They never appear to have been used for anything else.

The fact that nothing was ever assessed against any other bidder except McNichol is unimportant. The other bidders never could assume this in stating their proposed time of completion. In this connection the wording of this in the specifications and in the contract forms is worthy of note. In the specifications it says that the Director "is hereby authorized to deduct and retain out of the payment the sum of ——— dollars as liquidated damages, and not as a penalty, for each and every day occupied beyond the time so stipulated." In the contract form, "It is understood and agreed that the sum of ——— dollars per day shall be deducted," etc.

This may not be legally mandatory on the Director, but an ordinary bidder reading it would hardly dare propose a shorter time than that in which he would expect to do the work.

SAFEGUARDING THE CONTRACTS AGAINST OTHER BIDDERS.

This threat in the specifications, with so strong a statement in the contract form, was probably the most potent means used to prevent contracts going to the wrong parties, except possibly the combination of lump sum bids with short periods of advertising in local papers of small circulation. Examples of this are given above. Another may be seen in the advertisement for the opening of bids for No. 29, for the construction of Lardner's Point Pumping Station No. 2. The following is the schedule of papers and the dates the advertisements appeared, from which the length of time the notice was before the public can easily be computed. The bids were opened Aug. 12, 1902:

"Item," Aug. 2 and 4.
"Demokrat," Aug. 2 and 5.
"Inquirer," Aug. 2, 4 and 5.
"World," Aug. 3.
"Transcript," Aug. 3.
"Dispatch," Aug. 3.

This was advertising for the preparation of lump sum bids for a large work, the lowest bid for which at this letting was nearly three-quarters of a million dollars. It included a structural steel, brick and terra cotta pumping station of elaborate design; high chimneys and their foundations; river intake with subaqueous gates, cofferdams and dredging, massive concrete foundations for heavy pumping engines, reinforced concrete conduits, excavations in quicksand, complicated water-tight valve chambers and pump wells; boiler foundations, smoke tunnels and a host of about as complicated items as could well be put in one contract.

144 PAGES OF SPECIFICATIONS.

Elaborate specifications, filling a printed volume of 144 pages, 329 sq. ft. of closely drawn detail maps—all had to be studied out, the quantities estimated and the prices determined, before a bid could be prepared. The notice given was just ten days, and this by advertisement of a strictly local kind.

From what has been shown above and from abundant evidence that has been presented to us, there can be no doubt that local contractors generally had been fully educated to the futility of bidding on city work. The above advertisements did little to attract foreign contractors, who might have the temerity to "rush in where" Philadelphians "feared to tread."

Some rather burdensome laws and ordinances concerning contracts were used and added to in a manner that must have helped eliminate competition. These require that a bidder must file a bond of $500 with the City Solicitor, paying a small fee. He must also secure a bondsman to be bound with him for a large penal bond if he gets the contract. Then he must be ready to give another bond equal to half the amount of the contract to insure its faithful performance. These would seem discouraging enough to prevent people from lightly bidding, but there was added the necessity of depositing $10 to $100 to get specifications and a certified check for sometimes as high as $40,000 had to be deposited with each bid. The bondsman once named could not be changed, and for some reason bidders outside of a certain few could not get surety companies to go on their bonds for Philadelphia city work.

The reason for this we have not yet fully ascertained, but as it was known to bidders it should have been known to the officials. We have found no efforts on the part of the latter to change this condition or otherwise relieve bidders from it. After a bidder had gone through all the trouble and expense involved in bidding under the conditions described above, and being the lowest bidder had seen the contract given arbitrarily to McNichol or Ryan & Kelley or readvertised, it is easily seen how he would soon quit bidding on city work.

OUTSIDE CONTRACTORS WOULD NOT BID.

We have received testimony from many contractors that the conditions described above kept them from bidding. We have also received statements that city officials directly discouraged bidders from submitting bids. This field has not yet been fully explored.

A provision in all the contracts for filter sand and gravel required the bidder to submit his samples at least three days before the opening of bids. This gave a good opportunity to find out in advance who were going to bid.

McNICHOL'S BID EXCEEDED ESTIMATE BY $2,000,000.

The Bullitt law governing city contracts requires that "every contract for public improvement shall be based upon an estimate of the whole cost, furnished by the proper officer through the department having charge of

the improvement, and no bid in excess of such estimate shall be accepted." We find that this law appears to have been generally complied with, so far as making the preliminary estimates was concerned, but thereafter it was generally violated, as the large contracts, wherever we have been able to make comparisons, were frequently for sums much in excess of the estimates.

For Contract No. 25, Torresdale filters, McNichol's accepted bid exceeded the official estimate by nearly two million dollars. For No. 14, for Torresdale conduit, his accepted bid exceeded the estimate $425,000, and No. 23, for pipe lines, $235,000. Contract No. 25, on which the excess was nearly $2,000,000, was for 55 filters.

Another contract, No. 54, was subsequently let for ten more filters alongside the others. On this McNichol's accepted bid only exceeded the estimate by $20,000, but there were some remarkable deviations in the figures of the estimates.

For instance, excavation in the first case was estimated at 30 cents a cubic yard; in the second at $1 a yard. The character of the excavation in the two cases is precisely the same.

The second estimate was markedly higher than the first in the following items among others: Earth fill, dry brick walls, piling and expanded metal were assumed in the second estimate at twice the prices used in the first. Concrete was increased 24%; brick masonry 75%. Cast iron was increased to 2½ times its former estimated cost. Steel was increased 75% and lumber 50%.

These changes in the estimated figures made less discrepancy, of course, between the estimate and the bid. The bids were about the same and essentially the same prices were used in computing the monthly estimates for payment in each contract. As the contractor had all his plant on the ground that he had used in building the other 55 filters adjoining, it is a little remarkable that he did not offer to do the work at a much lower price. These ten filters were originally designed to be built at the Queen Lane Reservoir. This plan was changed in time to let the contract so that the work just followed McNichol's completion of No. 25.

BIDS EXCESSIVE OF OTHER CONTRACTORS.

Ryan & Kelley's accepted bid for Belmont exceeded the estimate by $428,000.

We do not find these large discrepancies on contracts let to other people. George C. Dietrich had an excess of $22,000 on No. 29, and R. A. Malone & Co., $1,500 on No. 27, each contract being for over half a million dollars.

We are unable to give full comparisons between accepted bids and the estimates, because the only complete files of the latter were removed from the office by Mr. Hill just before he resigned, and we have been unable to secure their return. Our figures given above are made up from extra copies that happened to be in the possession of assistants and by consolidation of some of the partial estimates from which the originals in Mr. Hill's possession were made. There are many that we have been unable to reconstruct or otherwise obtain as yet.

We find no record of many official matters that should be in the files, but a profuse record of unimportant things. The indexes were kept in such shape that it is impossible to tell whether or not the missing papers were ever in the files—many papers, by Mr. Hill's order, not being indexed at all.

SPECIFICATIONS NOT ENFORCED.

In the execution of the contracts there is a wide field to investigate. We have not been able to cover it all, but we have found many cases where the vague paragraphs in the specifications giving undue authority to the city officials have been used to harass certain contractors and to favor McNichol and Ryan & Kelley. For instance, the paragraph in Ryan & Kelley's contract for Belmont, calling for replacing unsuitable foundation with concrete, without charge, was not enforced.

When a poor piece of ground was encountered it was not removed and filled with concrete free of cost, but a grillage of timber was placed under the puddle and paid for as an extra.

$28,000 PRESENTED TO McNICHOL.

Similarly, McNichol in contract No. 25, which had the same provision, instead of being required to put in concrete free of cost was allowed to put in cobbles and gravel and was paid for it at $1.38½ a cubic yard, the amount paid being $28,349.57. In recommending this payment Mr. Hill states under date of January 22, 1903: "I do not think that the ordinary saving clauses in this contract would require the contractor at his own expense to construct the work as herein mentioned."

The contract provides specifically for precisely the opposite. It says: "Par. 34, additional depth: If in the opinion of the engineer, the foundation when uncovered is not satisfactory, the contractor shall carry the excavation to such additional depths as may be directed and shall fill up to the under side of the puddle with concrete prepared and mixed, as specified under concrete, without additional cost to the city."

As the contract provided for additional concrete at a bid price we can see absolutely no reason for putting this great contingency on the contractor in the specifications, except to frighten bidders.

But it is there definitely and unequivocally, and releasing Contractor McNichol from it was wholly improper. The payment to him of $28,000 for filling the place was precisely the equivalent of a presentation to him of that much of the city's money. Had he been compelled to comply with the specifications, it would have cost him four or five times that amount. Why the above paragraph in the specifications should be considered merely a "saving clause" we cannot understand.

In the filter contracts we find an unusual paragraph, requiring the faces of concrete walls to be made of a stiff granolithic mortar "which shall be deposited by skilled workmen against the face forms with a least thickness of one inch, in advance of and supported by the backing concrete, the stones of which shall be well worked back from the face." This difficult operation must have deterred many bidders or caused them to bid high prices. We find little indication that it was ever enforced. All these filter contracts went to McNichol and Ryan & Kelley.

CONTRACT 25 CHANGED IN CONTRACTOR'S FAVOR.

An extensive change was made on contract No. 25 in the main collector drains for filtered water, lessening the cost to the contractor. On Chief Engineer Hill's recommendation the contractor's price was lowered $3,536.90 for this. Computed in accordance with the specifications, we make the proper deduction to be $12,300.90.

Similar changes and deductions were made on Belmont for Ryan & Kelley and on both Roxboroughs for D. J. McNichol.

On contract No. 28 the work consists in providing three lines of large pipe side by side. Contractor McNichol's price for excavation includes back filling the trench after the pipe is laid and ramming the earth and gravel under and between the pipes. This is a rather difficult operation, as the pipes are 60 ins. in diameter and only a short distance apart. Instead of being required to do this, he was paid for it just the same and also paid extra for filling under and part way up the sides of the pipe with concrete at $7.75 a cubic yard. As the cost of hauling, depositing and ramming of the earth and the concrete are practically the same, this price has to cover only the materials and the mixing of the concrete, which is not worth over $5.50 per yard, 20% profit included; 5,758 cu. yds. have been used, entailing a loss to the city of $12,957.50.

This arrangement was made by Chief Engineer Hill without any competition.

McNICHOL BORROWED PIPE FROM WATER BUREAU.

On McNichol's contracts Nos. 17 and 19, for pipe lines, we find that the contractor was permitted to borrow pipe and special castings from the Water Bureau without any limits and without any accounts or records worth mentioning. The same teams that hauled for the Water Bureau hauled for the contractor. The men in charge of the yards had telephone orders to let the contractor have anything he wanted.

We have devoted a great deal of time to an attempt to have made a complete audit of the pipe involved, and we find in the Water Bureau only a few disconnected memoranda and no useful accounting at all. Water Bureau officals claim that the Filtration Bureau was to keep the records.

We have much evidence that the contractor borrowed a great deal more than he returned, and that Chief Engineer Hill knew of the lack of records in the matter and helped to prevent proper records being kept. The authority to lend the pipe came to the chief engineer of the Water Bureau by telephone from the Director of Public Works.

The above are typical samples of the manner in which Contractors McNichol and Ryan & Kelley were favored; and we find nothing in the execution of the contracts to offset them. We have not yet fully examined all the records, but wherever we do examine we find similar conditions.

TREATMENT OF "OUTSIDE" CONTRACTORS.

On the other hand, we find that when others than Ryan & Kelley and McNichol got large contracts they received decidedly different treatment. There were only two of these, outside of contracts for machinery. They were R. A. Malone & Co., for the Oak Lane reservoir, contract No. 27, and George C. Dietrich, for Lardner's Point Pumping Station, No. 2, contract No. 29.

In the first of these the treatment consisted in the rigid and literal enforcement of severe specifications. The work was practically finished nearly a year ago, but over $50,000 is still held up pending some tests, not in the specifications, but, perhaps, inferable from them.

In the other case the specifications appear to have been not only rigidly enforced, but the chief engineer assumed many prerogatives not provided by them to the serious injury of the contractor. This contractor, financially ruined, makes a profusion of claims and charges; but we have not in this matter or in any others constituted ourselves a court to balance opposing claims, and we therefore only use in this report such statements as are borne out by the records or verified by the assistants who represented the city in direct charge of the work.

HOW DIETRICH WAS HARASSED.

We find that Mr. Hill refused to allow Mr. Dietrich to make the connection between his conduit and Shaft No. 11 of McNichol's Torresdale conduit until the latter had finished and quit pumping. This was wholly unwarranted and caused Mr. Dietrich much expense, as he had to make the connection in the face of a flow of water from the conduit of about 1,000,000 gallons a day. There were two reasons given for this order—one, that some water might run down McNichol's shaft. This is untenable. Enough could not have gone down there to endanger life, and Mr. Dietrich could have easily been held responsible for any other damage. The second reason, that the contractor had too much excavation open on another part of the work, was an interference on the part of Chief Engineer Hill that we cannot justify.

Mr. Hill did not treat Mr. Dietrich fairly in the matter of giving him information as to cement tests. On one occasion, instead of notifying him promptly as to the tests of the cement, he waited till he was at the bottom of a deep excavation in quicksand and then told him his cement, 5,400 barrels, was all rejected. The cement was an excellent and uniformly reliable imported brand. The chief engineer afterward permitted every barrel of it to be used—but not till after the delay had caused a break in the sides of the deep excavation.

After the delay due to the cement question had passed, the excavation was kept open about three weeks longer, till Mr. Hill recovered from an illness and made a personal inspection of the bottom of the pit and had consumed eleven more days making drawings for wooden grillages to be put under the pump well and the six engine beds, which were rectangular masses of concrete, each weighing 850 tons. Then the work was allowed to proceed. The grillages spread the foundations only a trifle.

Through a mistake in one of Mr. Hill's drawings, gate chamber No. 1 had to be moved several yards, but this was not done till Mr. Dietrich had been forced to spend several months trying to accomplish almost a physical impossibility that would not have been essentially different from the modified plan if he had succeeded.

DIETRICH'S MIXER CONDEMNED, USED BY McNICHOL.

The specification required that concrete should be mixed in a cubical mixer. Owing to lack of space, Mr. Dietrich bought another type, a McKelvay mixer. It was on the ground a long time and seen by Mr. Hill without objection. After it had been in use some time and had become a second-hand machine, he condemned it. The identical machine was afterward used by McNichol on contract No. 28 under identical specifications. Mr. Dietrich then bought a Chambers mixer. This was condemned by Mr. Hill, after it had become second-hand, on the ground that it would not make good concrete.

Afterward, Ryan & Kelley used a duplicate machine on the duplicate pumping station alongside. Their specifications were different, but the concrete should have been the same, and in both cases the mixer had to be approved by the engineer. Previously, they had used a mixer other than cubical on Belmont filters, under specifications the duplicate of Dietrich's. Mr. Dietrich had to get a cubical mixer and, for want of room elsewhere, had to set it up on one of the engine beds. Ultimately, he was allowed to mix some concrete by hand and arranged derricks for its convenient handling. Mr. Hill then compelled him to put a roof over the mixing board to keep the concrete from freezing. This prevented the use of the derricks, and, by shading the concrete, made more danger of freezing.

When the contract was let in detail, plans were still unmade. Mr. Dietrich's contract should have been completed Aug. 22, 1903; the detail drawings are several of them dated nearly a year later.

SCREWS PUT ON DIETRICH.

When Mr. Dietrich was ready to begin laying the brick walls of the engine house, Mr. Hill concluded that one of the walls in his design was too weak; so, after a three weeks' delay, on Dec. 7, 1903, he sent plans for buttresses to be built. Meantime, the wall between the buttresses had been partly built up, and much trouble and expense was occasioned thereby. Mr. Hill's new buttresses went clear down to the bottom of the foundations and new pits had to be dug, pumps installed and everything done over again. Nothing but the bid price for extra concrete was allowed; nothing for the additional pumping, loss of time, etc.

On the other hand, when, in contract No. 25, a change was made in the under-drains increasing the quantity of concrete and lessening the other materials and providing work much more easily done than that bid upon, Mr. Hill made a special increased price for concrete for the benefit of Mr. McNichol.

Through conditions in the specifications that never came into play in any other contract, Mr. Dietrich was for a long time almost denied access to his work. McNichol had a contract on the north and another on the south side of him. One of them was a pipe line on Robins street, which unimproved street Dietrich had filled and graded at his own expense and was using to reach his work. This contract was let subsequent to Dietrich's and no pro-

vision was inserted in it to prevent the work interfering with the previously let contract.

By Mr. Hill's order, Dietrich was forced to vacate his street in June, when it was promptly dug open by McNichol from curb to curb and stayed that way without a piece of pipe being laid till November. As a result of the work of Hill and McNichol, at one time, Dietrich's sole access to one side of his building was limited to the width of a single plank foot bridge. He could claim as a right under the specifications only the exact ground occupied by the structure and actually could not get to it on the ground, except by Mr. Hill's permission.

HILL'S POOR OPINION OF DIETRICH.

Whether this remarkable hampering was, as Mr. Dietrich claims, a part of a scheme to drive him from the field as a competitor or was purely accidental, it remains that he was greatly hampered and Mr. Hill must have known it. Nevertheless, we find that Mr. Hill, in a letter to Director Costello, dated February 25, 1904, after figuring Mr. Dietrich the lowest bidder for No. 68, the second half of the pumping station, recommends against him in favor of Ryan & Kelley, as follows: "I also regret to state that the manner in which the contractor has conducted his work does not inspire me with any great amount of confidence of his ability to complete the work under contract No. 68 within the time specified."

No mention is made in this letter of the stringent conditions as to space under which the work was performed. Nothing is said of the contractor's expensive and long drawn out efforts to make chamber No. 1 occupy part of the pump well of the old pumping station, where faulty plans had put it. Nothing of the numerous changes made in the plans. Nothing of the time lost due to the condemnation of a shipload of cement that afterward proved to be of an excellent character or of the delay caused by Mr. Hill's failure to give prompt notice of its alleged defects. Nothing is said of the delays caused by requiring needless changes in concrete mixers or demanding a roof over the mixing boards, preventing the use of the derricks. Nothing of the fact that when the letter was written many of the detail plans had not yet been furnished, and nothing of the needless delay waiting for Mr. Hill to get well and decide the question of a useless grillage under the engine beds and the wait with the pit open for a careful drawing of this grillage to be made. Nothing of the resulting unnecessary breaks into the pit due to quicksands.

INFERIOR MATERIAL ACCEPTED FROM SUB-CONTRACTOR.

In addition to those mentioned above, we find in the execution of this contract many other striking contrasts to the work of others. Mr. Dietrich gave up trying to make concrete and sublet his concrete work. As soon as this was done and the price Mr. Dietrich had to pay became fixed, the subcontractor was not required to use a cubical mixer, but to mix entirely by hand. Sixteen carloads of stone crushed finer than the specifications required had been rejected for Mr. Dietrich. He sold them for a small price to the subcontractor, who was allowed to use them.

In the bottom of excavations, Dietrich was required to get the bottom dry before he could lay his concrete. Ryan & Kelley were allowed to lay it in twelve inches of water under the same specifications. Dietrich was compelled to remove the fine crushings from his broken stone; McNichol and Ryan & Kelley were not. The stone was all from the same quarry and of exactly the same qualities, cars being shipped indiscriminately to each of the three contractors, and the specifications were the same.

After the numerous causes, delay and expense discussed above had bankrupted Mr. Dietrich, Mr. Hill made strenuous exertions to have him assessed $78,000 for overtime.

There were numerous other matters in which Mr. Dietrich claims he was harassed or discriminated against, but the above, which we consider established, seem to be enough on the subject.

CHANGED FILTRATION PLANS.

The original plans for filtration were formulated by a commission of experts in 1899. They have been departed from in three important particulars, viz., the construction of the Torresdale conduit, the transfer of the Queen Lane filters to Torresdale and the construction of the Oak Lane reservoir.

The Torresdale conduit is about three miles long. From its lower end to the city the water is to be carried by four lines of 60-inch pipe. The original plan was to continue this pipe up to Torresdale, instead of constructing the conduit. It would have cost about $100,000 less than the conduit.

The advantage of the conduit over the pipe line is that it would take more than 4 60-in. pipes to carry the water with the same amount of friction as would exist in the conduit.

The advantages of the pipe line over the conduit are numerous. The pipe line is more accessible for repairs and can readily be enlarged in the future. Its capacity can be increased without enlargement by forcing the water through under greater pressure, whereas the capacity of the conduit is limited to what will run by gravity.

This latter fact, that it does run by gravity, looks like an advantage, but the water delivered through the conduit by gravity reaches the lower end at a reduced elevation, and has to be elevated again by the pumps to get it into the pipe line.

This pumping would cost about as much as would the extra pressure to overcome the extra friction of the longer pipe line.

A further disadvantage is the necessity with the conduit of having two pumping stations. Under the commission's plan, one station at Torresdale served to pump the river water to the filters and the filtered water to the city. With the conduit, two stations with double administration and supply must be maintained.

In case of an accident to the filter system, it might be necessary to pump water to the city for a short time directly from the river, and provision has been made for this at Lardner's Point at the lower end of the conduit. The river water there is very much worse than at Torresdale and probably always will be.

DANGERS OF A BREAK IN THE CONDUIT.

The most serious defect of all is the fact that a break in the conduit might, under certain conditions, let in sewage contaminated water, and the trouble, if located, could not be repaired without paralyzing the water supply.

One difference between the two plans is that there was likely to be less competition for the contracts to construct the tunnel than there would be for the pipe lines, especially if the specifications, like those for this conduit, provided for the engineer having the privilege of compelling the contractor to construct a rock tunnel with a shield and could make him do the work in compressed air if he chose.

The determination to change the Queen Lane filters to Torresdale and build the Oak Lane reservoir must have been made before June 12, 1901, because on that day Chief Engineer Hill recommended the passage of ordinances of Councils to abandon the ground that was to be obtained at Queen Lane for the filters and to obtain the land for the Oak Lane Reservoir.

The contract was not made, however, till July 28, 1904, when it could be built by Contractor McNichol in a convenient succession to the Torresdale filter contract.

We have been unable to find any recommendation on file from any one covering the reasons for this important change. It is now planned to abandon the Queen Lane pumping station and move the pumps to Lardner's Point.

The Oak Lane Reservoir is designed to act as a kind of safety valve to the pumps at Lardner's Point. The supply to the city is to be furnished by direct pressure from the pumps.

When the demand for water decreases, the water will back up into Oak Lane Reservoir at an elevation of 210 ft. When the demand increases, the water will flow from the reservoir and add to the supply coming from the pumps.

Queen Lane Reservoir is 28 ft. higher than Oak Lane and is more suitably located than the latter for the purpose desired, and is apparently useless under the present plans.

NO NEED OF OAK LANE RESERVOIR.

We can find no need, therefore, for building the Oak Lane Reservoir.

It should be noted though that had R. A. Malone not bid on this work and built it for $532,000, there is nothing in the history of tae Filtration Bureau to justify the belief that Contractor McNichol would not have built it at a profit of about $800,000. We can find no other reason for its having been added to the plans. The two and a half miles of pipe line to connect it with the city, for which McNichol has the contract, will cost about $175,000.

$6,000,000 OVERCHARGE FOR FILTRATION SYSTEM.

The total cost to date of the filtration system as built, including all the small contracts, is $18,775,000, and the excess cost over proper prices is $5,955,317.

The estimated cost to complete the system is $6,542,000, including a new pumping outfit at Shawmont, new boilers at Belmont and $3,000,000 for new pipe lines. This last has, heretofore, been taken at $1,750,000.

Omitting the unnecessary Oak Lane reservoir and its connecting pipe line, the cost to date has been more than enough to have completed the entire system as above.

While the city on filtration contracts alone has suffered the above tremendous loss of $6,000,000 in money, a more serious loss has been in the lack of filtered water.

The work could readily have all been done in three years. John W. Hill came here and took practical charge of the work at the beginning of 1901. He had been consulting engineer previously, and about a year had been spent in preparatory work, the first contract for filters having been advertised about the end of the year 1900.

Allowing that year's work extra, the whole plant should certainly have been in operation three years later, or Jan. 1, 1904.

NO ONE CONTRACTOR COMPETENT TO DO THE WORK.

A proper distribution of the construction work, by means of itemized bids, among experienced contractors, would have accomplished this easily within the above time, and the work being done by contra[ctors who had] made a specialty of particular branches, [have in]sured to the city a completed system of fi[rst class work]. No one contractor or firm of contractors i[s to pos]sess the experience and ability to cope wit[h the many] varieties of construction work involved.

The filtered water district of West Phi[ladelphia has] been supplied with filtered water since June [1904. Dur]ing the sixteen months that have elapsed si[nce that date,] up to the first of this month, only ten per [cent of a] population of 41,000 in that district have di[ed of typhoid] fever, and even of these only one is properl[y chargeable] to this district, and even that one is uncer[tain.

At the same proportional rate, the deaths [in the whole] city, since January 1, 1904, when the filter[ed water sys]tem ought to have been completed, should [have been] 57 or less, whereas 1,257 have died. The dif[ference, 1,200] deaths, represents the loss of life due to [inferior methods] that have been employed in conducting the [work. The] entire amount necessary to complete the s[ystem could] have been borrowed at the beginning of the [year.

We have made complete lists of all the ab[ove deaths,] and have traced each case that occurred in [the filtered] water district mentioned.

Since January 1, 1904, the total number [of cases of] typhoid, including deaths in the city, was 11[,778. Had] there been a filtered water supply for the whol[e city dur]ing this period only a small percentage of th[ese cases] would have occurred, and in all probability typ[hoid would] practically not exist in the city to-day.

Respectfully presented.

CASSIUS E. GILLETTE,
Major of Engineers.
JNO. D. MACLENNAN.

NOTES FROM THE ENGINEERING SCHOOLS.

Cornell University.—The annual report of President Schurman, just issued, contains the following matter relating to the Colleges of Civil and Mechanical Engineering:

In the College of Civil Engineering the directorship, rendered vacant by the death of Professor Fuertes, has not been filled; but Professor Crandall has temporarily continued to carry the administrative work, which he has performed with self-sacrificing diligence and the utmost devotion. Owing to the considerable increase in the attendance of students and the restricted accommodation in Lincoln Hall, the problems of administration have been unusually difficult.

While the trustees have not, up to this date, been in a position to enlarge Lincoln Hall or furnish another building for the accommodation of the College of Civil Engineering they have, on the other hand, established ten new instructorships in civil engineering in order that the educational and scientific work of the college may be kept at its well-known efficiency. No such augmentation of the corps of instruction has been made in any other department or college of the university. Appropriations have also been made to provide for the conduct of the junior geodetic and topographic surveys in the summer vacation. And the enrichment of the regular four year course by the introduction of the new subjects of electrical engineering and steam machinery and the expansion of the subject of mining engineering necessarily increase the budget of the college.

Some modifications, in addition to those already mentioned, were made in the curriculum, one object being the reduction of the number of hours required for graduation. With greater concentration, work even more thorough than that done in the past can now be demanded of the student.

In the Sibley College of Mechanical Engineering and Mechanic Arts the new director has demonstrated his competency to continue and develop the splendid work of the late Dr. Thurston.

The policy of having the professors in certain technical departments spend alternate periods in teaching and in actual practice of engineering, is now firmly established; and the university not only encourages the temporary withdrawal of such professors but actually pays them to go out and secure engineering experience by granting them the benefits of the sabbatic leave as applied equitably to each individual case.

In the curriculum the dynamo-laboratory course hitherto given by the department of physics has been replaced by a new course in experimental electrical engineering, under the joint direction of the professor of experimental engineering and the professor of electrical engineering. The shop instruction, reduced from three hours a week to two, has been reorganized with a view to teaching and illustrating modern methods of manufacturing, thus abandoning the trade-school idea of manual dexterity or handicraft as an end. And shop work has been combined with machine design and drawing. This arrangement is not only practically convenient but logically desirable. For training in drawing is with a view to the design of machines and shop work shows these machines in action. Besides these changes the first year course in physics has been concentrated into one term instead of extending over the year, as had al-

ready been done with chemistry; the course in descriptive geometry has been cut down from two hours a year to two hours a term; a new course in hydraulics has been adopted from the College of Civil Engineering; and the senior year has been devoted, largely in the first term and almost wholly in the second, to specialized electives—courses not only in electrical, naval, marine, and railway mechanical engineering but also in the sciences of chemistry, physics and geology.

In a technical school it is no easy problem to hold the balance evenly between the claims of pure and the claims of applied science. At one extreme a curriculum may be too academic; at another it may be too practical, not to say commercial in its aspects. The Sibley course is now well adapted to the demands of the engineering and industrial world, with which Sibley professors are also required to keep in actual touch.

EXPERIENCE IN THE DESIGN OF SCREW PROPELLERS.*

By Horace See,† Member American Society of Naval Architects and Marine Engineers.

It is remarkable that natural laws are so often disregarded, particularly in the mechanic arts, and in no branch is it more strikingly illustrated than in the vessel driven by the screw propeller. We might say that here fantastic shapes are the most popular as shown in the propeller and the stern of a vessel. The propeller—like the Indian's boat—has received a dig from every passer-by and all sorts of shapes have been suggested for obtaining the highest efficiency. The expanding pitch with the tip of blade bent aft radially so as to assume a form like a spoon was at one time a prime favorite, but to-day has given place to the true screw. The latter after a thorough investigation was accepted by the writer to be the form, when properly designed, best suited for propelling a vessel whether the stern was full or lean, as it offered the least resistance in its path while obtaining maximum effect. The success with the bronze blade is in the same line, as it is to the thin blade, offering less resistance than the thicker iron one and not to the kind of metal

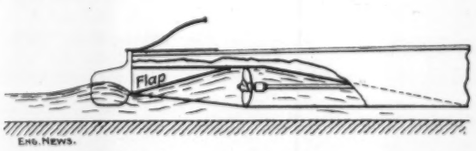


Fig. 1. Screw Propeller Placed in Tunnel, with Discharge Restricted by a Flap.

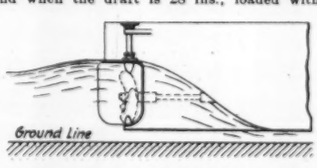


Fig. 2. Screw Propeller Tunnel With Discharge Free and Rudders at After End.

that this result is due. The frequency, therefore, with which this partiality for the spoon-shaped blade was expressed led the writer, when a contract had been obtained some twenty odd years ago for two vessels similar in every respect, to suggest in order to solve the problem that one be fitted with propellers having a blade in the form of a true screw and the other with spoon-shaped blades. These wheels were made solid, the outline as well as thickness of the blades being the same, the only difference being that the one was bent to form a true screw, while the other was expanded or twisted to make the spoon-shape. When the vessels were ready to launch with the wheels in place they were visited by quite a number of persons from whom the general expression was in favor of the spoon-shaped blade as it was claimed by them to take hold of the water better than the true screw. This view was quite correct in one way, but not in that desired for obtaining the best results in propelling the vessel, as the one with the true screw was driven at a speed one knot greater than that with the spoon-shaped screw. This result could not be attributed to the form of the one vessel or the character of its machinery being superior to that of the other, or to the handling of the vessels, but to the wheels themselves, as a new wheel of the true screw pattern when it replaced the spoon-shaped one brought the speed of this vessel up to that of the other. Again, when the one first fitted with the true screw broke this wheel and had the spoon-shaped one that had been taken off the other vessel placed on it—then her speed also was reduced as in the case of the vessel originally fitted with this wheel.

A tunnel arched longitudinally with its lowest point at the bottom of vessel forward of the screw, increasing and attaining its highest point over it and then descending to a point at or below the water line at the stern is another form of vessel propulsion that has fascinated many. The United States Government has had a number of vessels of this type built, the contractors for which have lost a considerable sum of money—some having gone into bankruptcy by failing to secure the contract speed. These boats were designed to maintain a speed of 29 knots for two consecutive hours. The "Perry" having attained but 28.2 knots on the progressive speed trials the contract speed demanded was afterwards reduced to 26 knots and the duration of run to one hour. The hook at stern was also removed and new propellers placed on two of the vessels. The "Paul Jones" gave the best general results—attaining after the change 28.91 knots on the progressive speed trials and 27.4 on the one hour's run. The location of propellers and the form of run, still being bad, worked against attaining a higher speed. The change of trim in this vessel is not given, but that of the others averaged 5½ ft.

The selection of this form of stern is more remarkable in view of the experience in 1889 with the dynamite gun cruiser "Vesuvius," contracted to attain a speed of 20 knots per hour, when tried in 4¼ to 5 fathoms or comparatively shallow water. The trials, four in number, with this depth of water were unsuccessful. The writer, who was present only on the last one, suggested after that failure a course where the depth of water would not be less than fifteen fathoms. This met with favor and when the next or final trial was made the vessel readily attained a speed of 21 65-100 knots or 1 65-100 in excess of the contract requirements. She had extremely fine lines with a wedge-shaped and not an overhanging stern. On this occasion she stood up without squatting aft and with but very little disturbance in the water, whereas, in the former trials the stern not only was depressed, but a wave was formed with the crest of it so high as to cover the deck at this point, thereby demonstrating that the water where depth is limited will, when leaving the stern, ascend naturally without mechanical means.

This now brings me to the tunnel stern with an adjustable flap, as shown in Fig. 1. Why a flap at all is difficult to understand, not only in view of the experience with the above mentioned torpedo boat destroyers, but also from the experiments with a shallow draft launch fitted with a tunnel and hinged flap of which it is stated in the Transactions of the Institution of Naval Architects, of 1903, page 109:

When the launch is light, drawing 11 ins., with the same power the speed is increased from 9.2 miles an hour with the flap down to 10 miles an hour with the flap up; and when the draft is 28 ins., loaded with 20 tons, the speed is increased from 6.9 miles an hour with the flap down to 8.25 miles an hour with the flap up, the power at both speeds being the same. As might naturally be expected, the increase of efficiency due to the lifting of the flap is greater when the boat is loaded, the lower speed in each case being what it would have been if there had been no adjustable flap, clearly showing the advantage of the flap.

Is not this an admission that the vessel would be better without the flap? Why should there be a flap if the boat does better with it raised? Why should it be employed to make the tunnel longer, thereby decreasing the displacement and with it increasing skin resistance? It is also said that "the rush of water being in an inclined direction towards the bottom, rather tends to scour it," but there is a failure to inform us whether the scouring leaves a true or a roughened surface. It is perfectly natural to suppose the latter is the case and that the flap, not only a disadvantage but also an unnecessary appendage, did project the water downwards to form holes, thereby retarding the vessel in shallow water and demanding greater power to do the work.

A screw, however, working in a tunnel with the air from the sides excluded and a free discharge aft seems to be a more desirable formation. It also seems that if the after portion of each side is made to form a rudder, as shown in Fig. 2, an additional advantage is gained in being able to steer a straight course, as the full surface of the rudders is brought into play, a result not accomplished with the flap as such a vessel is said to steer badly. The reason, no doubt, is that the water is projected downwards and away from the surface of rudder in proportion to the depression of the flap. With a double or twin rudder its position in this arrangement not only affords protection but also permits the quadrant or tiller being placed below the deck and also in a protected position.

The conclusions drawn by me from the above in reference to the movement of a vessel through a fluid have been as follows:

(1) That all vessels create one or more waves.

(2) That their character at the stern is partly influenced by the shape at this point.

(3) That the height of waves above the normal water level is governed by the speed of vessel through the water and the latter's depth under the vessel.

(4) That the wave at stern in shoal water answers the purpose of a flap without restricting the flow aft and with least resistance.

(5) That the discharge from a screw propeller should not only be free, but without restriction aft of it, no matter what the depth of water or at what speed the vessel moves through it.

(6) That discharging the water downward at the stern will scour the bottom and form holes to a greater extent than if discharged directly astern.

(7) That the depth of such holes will be in proportion to the intensity of the discharge and proximity of the wheel to the bottom.

(8) That a tunnel or form of stern directing the water to the screw propeller is valuable when its run limits the amount of skin friction and when it expands aft of the propeller.

(9) That the propeller should be placed sufficiently far aft to limit the skin friction from the stream set in motion.

*A paper read at the Milan Meeting of the International Navigation Congress.

†Consulting Engineer, 1 Broadway, New York City.

BREAKS IN PIPE SEWERS.

In discussions of leakages into pipe sewers more consideration has been given to pipe joints than to breakages in the pipe after construction. On this account many engineers will be interested in a paper on sewer pipe breaks read before the Sanitary Section of the Boston Society of Civil Engineers on Oct. 4, 1905, by Mr. Alexander Potter, M. Am. Soc. C. E., of 143 Liberty St., New York City. Aside from defective pipe, scarcely touched upon by Mr. Potter, breaks in sewer pipe are caused chiefly by the difficulties encountered in securing an unyielding foundation, bed or support for the pipe, and by the inelasticity of the joints. In dry sand, loam or clay the bottom of the trench may be shaped to the pipe, but in rock or in wet material an artificial bed must be prepared. In a wet trench it is practically impossible to backfill properly beneath and around large pipe with the material excavated from the trench. Instead, either concrete must be used to one-third the height of the pipe or else fine sand to the top of the pipe, the sand being flooded with water to make it fill around the pipe and form a firm bed. Where concrete is used it may be lean.

The author related some of his experiences in building 145 miles of outfall and collecting sewers for the Joint Sewer District of New Jersey, including portions of some of the Oranges, Summit, Millburn and a part of Elizabeth. About 65% of this mileage is through saturated glacial drift. Pipe in 3-ft. lengths was used.

In wet trenches a combined cradle and underdrain was used, consisting of 2 × 4-in. timber laid flatwise and parallel to the pipe, 6 ins. c. to c., then above and at right angles to these strips, 4 × 4-in. stuff, 18 ins. c to c. The pipe was laid on these cross pieces and was held in place by wedges nailed to the 4 × 4-in stuff. The space below the pipe acted as a drain, while the timber work raised the joints above the water. The cradle was cheaper than broken stone or gravel combined with a tile drain, but it left a larger space beneath the pipe to be backfilled.

Some broken pipe having been found, the contractor claimed that the breaks were due to the cradle, and asked permission to substitute broken stone or gravel and tile underdrain. This permission having been granted, the contractor took particular pains with his work thereafter, in order to justify the change.

The methods and results of inspections of the pipe as laid are set forth in the paper as follows:

A systematic inspection of all completed sections was then started and all cracked pipe either replaced or surrounded with concrete. On all sewers 20 ins. in diameter and over an assistant engineer crawled through every length of pipe laid. On sewers of smaller diameter an examination was made with the aid of mirrors. In some detail the record of breaks was as follows:

On 26,303 ft. of 24-in. pipe, most of which was standard thickness, 24 different breaks occurred on 24-in. pipe, aggregating 1,500 ft., each break running from 15 ft. to 150 ft. Nearly all of the breaks occurred either in gravel or rock cuttings. No breaks were found in quicksand. The proportion of breakage on gravel or broken stone foundation with underdrain to the total length of sewer laid with this class of foundation was much greater than the proportion of breakage on timber foundation to the total length of sewer laid on this latter class of foundation. The depths of cuts where breaks occurred varied from 6 ft. to 20 ft., but more broken pipes were found at the lesser depths.

On 8, 197 ft. of 22-in. standard pipe at depths varying

from 6 ft. to 20 ft., much of which was laid on timber foundation and none on gravel or broken stone, not a single cracked pipe was found.

Fourteen breaks occurred on 4,382 ft. of 20-in. pipe, aggregating 500 ft. in all. All of these breaks occurred in rock cuttings where the pipe was temporarily supported on blocks until selected material was rammed solidly around and under the pipe. A close inspection of the uncovering of the pipe revealed the fact that at certain places sufficient space had not been left at the springing line of the pipe to allow room for the proper ramming of the backfilling around the lower half of the pipe.

On a short stretch of 18-in. pipe laid on a heavy grade, the sewer collapsed shortly after construction, due to the flood of water washing out the newly filled in material over the sewer under the macadam pavement, which dropped on the pipe and ruptured it.

Concreting under all pipe in wet trenches on this work would have added $125,000 to the cost of the sewers, which was $1,680,000 for 145 miles of sewers. The total cost of replacing the broken pipe was less than $5,000. This did not stop all leakage, but the actual amount of leakage on the entire system was less than 15% of the capacity. Had concrete been gradually used and the same care given in jointing the pipe, the leakage could have been reduced fully 50%. The value of the additional capacity thus secured for sewage purposes would have been $148,170. In designing the sewer provision was made for ground water infiltration of 33% of the capacity. Had concrete been generally used and the

The writer is free to confess that he is not able to account in each case for the cause of the breakage. For instance, on one stretch of 2,000 ft. of 24-in. pipe not a single piece of cracked pipe was discovered, while next to it, under exactly the same conditions, but laid under another inspector, 800 ft. of pipe was broken nearly its entire length. I have no reason to think that one inspector was less efficient than the other.

. . . . . .

To what extent, if any, breakage is attributable to the use of 3 ft. lengths might form a basis of inquiry. A reduction of 33% of the number of joints is always a sufficient warrant for the use of 3-ft. over 2-ft. lengths of pipe, if there is no other offset save the small increase in cost. As 80% of the breakage on the work referred to occurred in ditches less than 10-ft. deep, the use of standard pipe on much of this work cannot account for the failure of the pipe.

As a result of his experience and observation the author concluded that no vitrified pipe 20 ins. and more in diameter should be laid except upon a concrete base, and that with sizes less than 20 ins. concrete should be used more generally than is now the practice.

POOR'S RAILWAY STATISTICS FOR 1904.

The advance sheets of the Introduction to "Poor's Manual" for 1905 have just been received, and we reproduce herewith the most important statistics there presented, summarizing the results of operation of railways of the United States for 1904, as follows:

	Miles.
Length of railroads completed on Dec. 31, 1904	212,348.72
Of which completed to close of fiscal years:	
Reporting traffic statistics, earnings, etc., complete ..... 206,482.37 m.	
Reporting gross earnings, but not traffic operations..... 974.41 m.	
Not reporting operations..... 3,617.61 m.	—211,074.39
Completed since close of their fiscal years.....	1,274.33
Net increase of mileage of all railroads in the United States in the calendar year 1904.....	5,013.87
Net increase of mileage of railroads reporting traffic operations in the fiscal year 1904.....	3,430.30

STATISTICS OF OPERATIONS, FISCAL YEAR 1904.

Miles of railroad reporting traffic statistics, earnings, etc.	213,294.78
Passenger train mileage	441,146,521
Freight train mileage	542,168,773
Mixed train mileage	28,020,221
Total revenue trains—mileage	1,011,335,515
Passengers carried	715,654,951
Passengers—mileage	22,167,124,184
Tons freight moved	1,275,321,607
Tons freight moved 1 mile	173,613,762,130
EARNINGS—Passenger	$455,067,129
Freight	1,367,119,507
Other	141,575,558
Earnings of 533.24 M. Switching RRs.*..	13,876,519
Total traffic revenue	$1,977,628,713
Operating expenses	1,338,388,636
Net earnings	$639,240,027
Other receipts	81,357,891
Total available revenue	$720,597,918
PAYMENTS from available revenue:	
Interest on bonds	$242,992,755
Other interest	13,651,590
Dividends	188,386,093
Rentals—Interest $32,807,445	
Dividends 23,136,073	
Miscellaneous ... 18,120,396—	74,063,914
Miscellaneous	54,557,670
Total	$627,977,878
BALANCE—Surplus over fixed charges and miscellaneous payments	$92,620,040

*This 533.24 miles is made up of switching, belt, terminal, connecting and toll railroads.

A SUMMARY OF EXPENDITURES ON THE ISTHMIAN CANAL.

There has just been made public a detailed summary of expenditures on the Isthmian Canal work up to the close of the fiscal year ending June 30, 1905. We print this summary as follows:

Balance Sheet, June 30, 1905.

Appropriation by Congress, June 28, 1902	$10,000,000.00
Receipts from all other sources to June 30, 1905	92,959.29
	$10,092,959.29
Expenditures to June 30, 1905	$4,009,543.76
Balance June 30, 1905	6,083,415.53
	$10,092,959.29

SUMMARY OF EXPENDITURES IN ALL DEPARTMENTS.

From June 28, 1902, to June 30, 1905.

General Expenses:	
The Isthmian Canal Commission	$137,714.57
Office of Committee on Engineering	5,783.67
Special Commissioners	14,329.02
Department of Administration:	
Office of Administration	67,961.72
The General Auditor—Washington Office	19,406.21
The General Auditor—Isthmus Office	5,331.33
Disbursing Officers—Washington Office	8,714.28
Disbursing Officer—Isthmus Office	18,406.37
The Land Department	5,100.60
Department of Government and Sanitation:	
The Executive Office	29,223.05
The Zone Treasurer	665.00
The Administration of Justice	13,501.30
The Collector of Revenue	23,916.30
Department of Construction and Engineering:	
Office of Chief Engineer	161,505.82
Principal Assistant Engineer in charge of Records and Office	9,477.88
Mechanical Engineer	9,138.48
Office of General Manager, Labor and Quarters	14,358.68
Bureau of Water-Works, Sewers and Roads	10,198.97
Bureau of Architecture and Buildings	6,736.14
Bureau of Telegraph, Telephone and Electric Lights	2,348.28
Bureau of Meterology and River Hydraulics	342.33
Bureau of Map Making, Lithography and Printing	11,501.52
Sanitation	208,641.05
Hospitals and Asylums	169,852.86
Construction of Water-Works, Sewers and Roads:	
Improvement of Zone Highways	9,277.50
Street Improvement—Panama	606.72
Construction of Water-Works and Sewers.	186,154.16
Police and Prisons	67,594.12
Canal Construction	694,292.33
Machine Shop Expenses	167,841.44
Repairs to Equipment:	
Repairs of Excavating and Dredging Machines	8,438.45
Railroad Construction and Repairs of Railroad Equipment	42,728.73
Repairs of Miscellaneous Equipment	24,367.31
*Material, Supplies and Equipment purchased	1,087,726.64
*Cost of Purchase, Handling and Transportation of Material and Supplies:	
The General Purchasing Officer—Washington Office	17,470.85
Assistant Purchasing and Shipping Agents—New York Office	4,931.48
Asst. Purchasing and Shipping Agents—New Orleans Office	695.35
Material and Supplies Division on Isthmus	203,750.71
Freight, Advertising, etc.	21,038.65
Purchase of La Boca Shops	8,425.79
Purchase of Land and Buildings	46,290.00
Construction and Repair of Buildings	305,100.61
Purchase of Panama Railroad Stock	155,657.49
Total	$4,009,543.76

*Ultimately the amounts shown in these items will be distributed among the departments receiving the material when completed reports shall have been rendered.

THE OPERATIONS OF THE SEWAGE WORKS OF MANCHESTER, ENGLAND, 1904-5.

The remodelled sewage works of Manchester, England, have for some months been able to treat all the sewage except a small portion of very heavy storm flows. The treatment, however, does not yet include passage through the second contact beds for which provision has been made. For the present reliance is placed on detritus and open septic tanks, followed by single contact beds, with sedimentation and storm water beds for the heavier storm flows up to a dilution of 5 to 1. Chemical precipitation has been used less and less as portions of the new works have been put in commission, and on Aug. 4, 1904, the use of chemicals was discontinued.

The population of Manchester by the British Census of 1901 was 543,827. The population connected with the sewers leading to the Davyhulme works was about 575,000 early in 1904.

According to the report of the Manchester Rivers Department (Sir B. T. Leech, Chairman Rivers Committee) for the year ending March 29, 1905, the total volume of sewage passing to the Davyhulme works for the year was about 13,000,000,000 U. S. gallons. This was at the average rate of about 36,000,000 U. S. gallons per day. The greatest daily flow recorded was about 48,000,000 U. S. gallons on Monday, Aug. 22.

At 7 a. m. of the day named the rate of flow was about 208,000,000 U. S. gallons per 24 hours. The per capita flows, ranged as follows: Minimum, 51 U. S. gallons, for four weeks ending Oct. 12, 1904; maximum, 81 U. S. gallons, for four weeks ending March 29, 1905. Although the total rainfall of 36.5 ins. was less than in the previous year yet it was measurable at Davyhulme on 57 of 364 days during 1904-5.

During the year in question only 38,000,000 U. S. gallons of sewage was diluted beyond the 5 to 1 (5 parts storm water to 1 part dry weather flow) limit which the works were designed to treat, either wholly or in part. This amount is so small a percentage of the whole that it may be ignored. Of the approximately 13,000,000,000 U. S. gallons treated some 2,000,000,000 gallons had either chemical treatment or sedimentation, only, while 11,000,000,000 U. S. gallons was passed through either the single contact beds or the storm water filters. Of the 11,000,000,000 gallons, about 7,500,000,000 gallons was treated in open septic tanks; some or all of the remainder, as we understand it, had the benefit of plain sedimentation. During the last two quarters of the year 98.5 and 99.6%, respectively, of all the sewage passed through either the single contact beds or the storm water filters.

The labor and incidental expenses connected with the single contact beds and storm water filters during the year averaged 3s. 11.3d. per 1,000,000 Imp. gallons or about 80 cts. per 1,000,000 U. S. gallons. This included no allowance "for future renewal or washing of the material of the beds."

The amount of sludge removed from the septic tanks during the year was 72,310 long tons or 11 tons 14 cwts. per 1,000,000 Imp. gallons (21,840 lbs. per 1,000,000 U. S. gallons). For the preceding year the average was 6 long tons per 1,000,000 Imp. gallons, making an average of 8 long tons, 17 cwt. of sludge per 1,000,000 Imp. gallons of sewage receiving septic treatment as compared with an average of 18 long tons, 2 cwt. under chemical treatment from 1899 to 1901. To make a fairer general comparison the sludge removed from the sedimentation tanks should be added to that from the septic tanks, giving an average for the two last years of 2,800 long tons of sludge per week, as compared with 3,920 long tons per week under chemical treatment in 1899 to 1901. During 1904-5 the sludge removed from the septic tanks contained from 80.3 to 91% of water, as shown by analyses reported for weekly periods. The average for the year is not given, but apparently it was about 85%.

Two methods of removing sludge from the septic tanks without drawing off the sewage were tried during the year. The use of a portable centrifugal pump, driven by an oil engine, indicated that such a method would be too expensive. For the next trial three circular manholes were built at the outlet end of a tank; one opposite the center and one on either side, midway between the center line and the side lines of the tank. The two outer manholes were connected to the central ones and this to a sludge conduit. Each manhole has five 9-in. cast-iron sludge inlets, with gates, thus making it possible to draw sludge from large areas. The report states that this means of sludge removal has been satisfactory. By opening each controlling valve, in turn, 200 long tons of sludge, containing 87% water, can be removed from one tank.

The area of half-acre single contact beds in use at the date of the report (July 31, 1905) was 42½ acres. Some of these beds were put in use during the year. Only seven beds remained to be completed to bring the area up to the proposed total of 46 acres. Of storm water filters there were in use during the whole year 28 acres. These beds are filled about once a day

during dry weather, thus keeping them in good working order, besides getting some good from them. To keep the beds in good physical condition it has been found best, during heavy storm flows, to work them as rapid cycle contact beds, rather than to allow the sewage to pond, thus working them like water filters. Three men have been employed to maintain the 26.8 acres of storm filters since Aug. 4, 1904, when chemical precipitation was stopped. The general practice is to harrow the surface of the storm water beds, but in several of the latter there has been "a tendency for the material to set into a light layer immediately below the depth to which the tynes of the harrow penetrate." In such cases the beds have been forked to a depth of 4 or 5 ins.

For the whole period under review analyses showed that the raw sewage contained 0.49 parts per 100,000 of albuminoid ammonia, and 14.1 parts of chlorine, while corresponding samples of septic tank effluent showed 0.23 parts of albuminoid ammonia and 10.3 parts of chlorine. Another set of samples, designed to show the effect of the single contact bed, showed 0.33 parts of albuminoid ammonia in the tank effluent and 0.13 in the bed effluent, being a reduction of 61%, or of 73% if calculated on the raw sewage. These figures were averages for one of the groups of the older beds, working at the rate of 520,000 U. S. gallons per acre per day for the year. Another group of older beds showed slightly better results while working at an average daily rate of 615,000 U. S. gallons.

The storm water beds were dosed with sewage which for the year averaged as follows, at different stages: Chlorine, 14.1 for raw sewage, and slightly weaker, in succession, for tank and storm bed effluents. Albuminoid ammonia, 0.49 for raw sewage, 0.265 for tank effluent and 0.11 for storm bed effluents. The storm bed effluent showed a reduction of 58% calculated on the tank effluent and 78% on the raw sewage, the average daily quantity dealt with being in round numbers about 350,000 U. S. gallons per acre.

The unit rates of filtration given just above were, of course, greatly exceeded at times. The record week for the whole year was the one ending March 15, 1905, when about 307,000,000 U. S. gallons or some 52,500,000 U. S. gallons a day were passed through the combined area of the single contact and storm water filter beds. During this particular week the albuminoid ammonia in the raw sewage was 0.34, and in the average final effluent, 0.09, showing a reduction of 74%. The exact acreage of contact beds in use that time is not given. The report states that for the last quarter of the year contact beds 13 to 15 "dealt with the effluent from the open septic tanks at an average rate of practically 700,000 gallons [840,000 U. S. gallons—Ed.] per acre per day."

Besides the works at Davyhulme, Manchester is now responsible for two others, located in districts annexed to the city on Nov. 9, 1904. The Withington works, located at Chorlton-cum-Hardy, on the River Mersey, were originally laid out as a sewage farm, but have since been changed to sedimentation, followed by double contact beds. The total dry weather flow, including that from the Levenshulme district, treated here by agreement, is 3,600,000 U. S. gallons a day. The low level sewage is pumped by means of steam from refuse destructors boilers. There are ten acres of half-acre contact beds, divided equally between first and single contact; also two detritus and two settling tanks, the sizes of which are not given in the report.

The other newly added works, the Moss Side, treat about 1,000,000 gallons of dry matter flow by means of chemical precipitation, followed by application to 20 acres of underdrained land. The sewage from these works will be diverted to the Davyhulme works.

The main or Davyhulme works at Manchester have been built by the Rivers Department, with Mr. James P. Wilkinson, Assoc. M. Inst. C. E., 301 Cathedral Street, Manchester, as engineer, and with Dr. Gilbert J. Fowler, Broad Oak, Urmston, near Manchester, as superintendent and chemist in charge of operation and of experimental work. Within a year or so Dr. Fowler resigned the position just named and was appointed as consulting chemist to the Rivers Department.

ENGINEERING MATERIAL PRICES.

TRACK FASTENINGS—
Pittsburg f. o. b. cars—Angle bars, 1.75 cts.; spikes, 1.80 to 1.90 cts.; bolts, square nuts, 2.15 cts.; bolts, hexagonal nuts, 2.40 cts.

RAILS, STEEL—
New York—at mill—New standard sections, $28; standard, second quality, $27; light sections, 12 to 25 lbs., $24 to $26; old iron, f. o. b. New York, $21.50 to $22; old steel, long lengths, $16.50 to $17; old steel, short pieces, $16.25 to $16.50; relayers, $24.50 to $25.
Pittsburg—Standard sections, at mill, $28; standard, second quality, $27; light rails, 12 to 25 lbs., $24 to $30.

STRUCTURAL MATERIALS—
New York—at tidewater—Beams and channels, up to 15-in., 1.84½ cts.; over 15-in., 1.84½ cts.; angles, 3 x 2 and up to 6 x 6, 1.84½ cts.; zees and tees, 1.89½ cts.; steel bars, half extras, 1.74½ cts.

PLATES AND SHEETS—
New York—at tidewater—Sheared plates, tank, 1.74½ to 1.82½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 1.94½ cts.; still bottoms, 2.04½ cts.; fire box, 2.24½ to 3.05 cts.
Pittsburg—Tank, ¼-in., thick and heavier, 1.60 cts.; black sheets, 27 gage, 2.15 cts.; black sheets, 28 gage, 2.25 cts.

IRON—
Pig Iron:
New York—tidewater—Northern: No. 1 X Foundry, $18 to $18.25; No. 2 X Foundry, $17.50 to $17.75; No. 2 Plain, $17 to $17.25; Gray Forge, $15.75 to $16.25; Basic, $17.25 to $17.75. Virginia: No. 1 Foundry, $18; No. 2 Foundry, $17.60; Basic, $16.75 to $17.75. Southern: No. 1 Foundry, $17.75 to $18.00; No. 2 Foundry, $17.25 to $17.50; No. 3 Foundry, $16.50 to $17.00; No. 4 Foundry, $16.00 to $16.50; No. 1 Soft, $17.75 to $18.00; No. 2 Soft, $17.25 to $17.50 Gray Forge, $15.25 to $15.75; Mottled, $15 to $15.25; Basic, $17.75.
Pittsburg—f. o. b. cars—No. 2 Foundry, $16.85; Gray Forge, $15.85; Bessemer Iron, $16.85; Ferro Manganese, $62 to $65; Muck Bars, $28 to $28.25; Iron Bars, $1.70 to $1.75.
Cast-Iron Pipe:
New York—Carload lots, net tons, 6-in., at tidewater, $27.50.
Chicago—4-in. water pipe, $30; 6-in. and larger, $29, with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—
Asphaltum:
Ventura and other California asphalts, $20 to $21 per ton at New York; Trinidad refined, $25 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.
Cement:
Rosendale, in wood, 85 to 95 cts.; Portland domestic, in wood, dock, $1.55 to $1.60; German Portland, $1.90 to $2.10.
Copper:
Lake, 16.37½ to 16.62½ cts.; electrolytic, 16.37½ to 16.62½ cts.; casting, 16.12½ to 16.37½ cts.
Lead:
New York, spot, 5.20 to 5.40 cts.
Spelter:
New York, spot, 6.15 to 6.25 cts.
Tin:
New York, spot, 32.77½ to 33.25 cts.
Tar:
New York, $5.50 to $6 per bbl.
Pitch:
New York, $3 per bbl.

LUMBER—
New York, wholesale prices:
Piling—Spruce, ordinary cargoes, 6 to 7 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; 55 to 60 ft., 23 cts.; 60 ft. and up, 25 cts.; pine, 60 to 65 ft., $8.50; 70 to 75 ft., $10.50; 80 ft. and up, $16.
Railroad ties—Yellow pine, 6 x 9 ins. x 8 ft., 63 to 65 cts.; 6 x 8 ins. x 8 ft., 58 to 60 cts.; 7 x 9 ins. x 8 ft., 70 to 72 cts.; 7 x 8 ins. x 8½ ft., 66 to 68 cts.; 7 x 9 ins. x 8½ ft., 71 to 73 cts.

REPORTS ON THE USE OF COPPER SULPHATE for the prevention of algae growths in public water supplies are called for by the New England Water-Works Association to supplement the symposium on that and allied subjects presented a few weeks ago at the annual convention of that society. For the sake of completeness and uniformity a question blank has been prepared and sent to all persons known to have used or proposed the use of copper sulphate. The questions asked are as follows:

Place .....
Body of Water Treated.....
Capacity (mil. gals.).....
Area (acres) .....
Organisms causing trouble.....
Number present (standard units).....
Date of dosing with copper sulphate.....
Amount copper sulphate used (total, lbs.).....
Ratio (parts per million).....
Method of Application.....
Effects of Treatment.....
On Organisms .....
On Tastes and Odors.....
On Fish.....
Was Copper present in the water after treatment?.....
If so, in what proportion?.....
Volume of water taken for a test?.....
Analytical method used?.....
Did organisms reappear?.....
What ones?.....
In what time?.....
To what extent?.....
Supplementary dosing.....
Date .....
Amount used .....
Effects .....

Any of our readers who may have experimented with copper sulphate if they have not already received a copy of this question blank are requested to communicate at once with Mr. Chas. W. Sherman, Editor Journal, New England Water-Works Association, 14 Beacon St., Boston, Mass. Promptness is imperative to inclusion of information with the symposium, which is scheduled for the December issue of the "Journal."

THE BREAKING OF A WATER MAIN at 18th and Clark Sts., Chicago, Oct. 29, caused extensive damage to property and the loss of three lives, including two men in the tunnel of the Illinois Telephone Co. The water poured down a tunnel shaft and burst in the air lock of the tunnel, causing the compressed air to escape and the tunnel to fill with gas, which is contained in the soil. The engineman at the shaft went down to see how much damage had been done and was suffocated by the gas, as was his brother who followed about half an hour later. Three men then went down with ropes, but were almost immediately overcome, only one remaining conscious long enough to signal to be hauled up. The water flooded basements of residences and warehouses and washed out portions of the railway tracks before it could be shut off.

A GAS-POWER SINGLE PHASE ELECTRIC RAILway line was started in service on Oct. 19, 1905. The railway runs between Warren, Pa., and Jamestown, N. Y., and consists in part of lines which have existed for a number of years; recently it has been organized as the Warren & Jamestown Street Ry. The line is equipped with the Westinghouse single-phase series alternating-current motor system, and uses a trolley-wire pressure of 3,300 volts. Power is generated by two horizontal two-cylinder tandem double-acting gas engines, built by the Westinghouse Machine Co., of Pittsburg, Pa. Each has a capacity of about 500 B. HP., rated, and is direct-connected to a 200-KW. revolving field single-phase generator. The generators, which feed the transmission line directly (without step-up transformers), are operated in parallel. This is particularly difficult service in the present case, because large cars are used; only a small number of cars will be on the road at any one moment, and the use of alternating current makes it impracticable to use storage batteries, so that the full fluctuations of load will be thrown upon the engines. The engines use natural gas from the pipe system of a local distribution company.

PERSONALS.

Mr. Henry C. Hazzard, of New York City, has been appointed Secretary of the New York State Commission of Gas and Electricity.

Mr. H. Morton Stephens, formerly of Colwyn, Pa., is now Assistant Engineer of the National Railroad of Haiti. He is located at Gonaives, Haiti.

Mr. G. F. Stickney has resigned his position as U. S. Assistant Engineer to accept a position on the engineering staff of the New York State Barge Canal.

Mr. Homer A. Reid, Assoc. M. Am. Soc. C. E., was recently appointed to the position of Assistant Engineer, Bureau of Buildings, for the Borough of Manhattan, New York City.

Mr. J. C. Herring has been appointed City Engineer of Fulton, Mo. Mr. Herring is senior member of the Herring-Hertel Engineering & Construction Co., of Jefferson City, Mo.

Mr. J. H. Wingate, for the past ten years City Engineer of Roanoke, Va., has tendered his resignation to the City Council, to take effect as soon as his successor can be appointed.

Mr. J. B. Berry, M. Am. Soc. C. E., Chief Engineer of the Union Pacific Ry., has been appointed Chief Engineer of the Chicago, Rock Island & Pacific Ry., with offices at Chicago.

Mr. Arthur Warren has resigned his position as Manager of Publicity for Allis-Chalmers Co., of Milwaukee, Wis., and will sail for Europe Nov. 25 on an important journalistic mission.

Mr. C. H. McCullough, Jr., has been elected a Vice-President and the General Manager of the Lackawanna Steel Co. His headquarters, for the present, will be at the works at Buffalo, N. Y.

Mr. Geo. H. Frost, President of the Engineering News Publishing Co., sailed from New York on the "Princess Irene" of the North German Lloyd line on Oct. 28, and will spend the winter in Egypt and Italy.

Capt. W. J. Barden, Corps of Engineers, U. S. Army, has been relieved from duty with the Second Battalion of Engineers and will report to the Commandant of the Engineer School, Washington Barracks, for duty as an Instructor.

Mr. Everett E. King, formerly Assistant Engineer, Maintenance of Way, for the Chicago, Rock Island & Pacific Ry., has been appointed Division Engineer of the Pacific & Idaho Northern Ry., with headquarters at Weiser, Idaho.

Mr. W. L. Darling, M. Am. Soc. C. E., who recently resigned his position as Chief Engineer of the Chicago, Rock Island & Pacific Ry., has been appointed Chief Engineer of the Pacific Ry., which is to build a line from Seattle to Wallula, Wash.

Mr. F. A. Delano, M. Am. Soc. C. E., has been elected President of the Wabash Ry. system, succeeding Mr. Joseph Ramsey, M. Am. Soc. C. E. Mr. Delano was for many years with the Chicago, Burlington & Quincy Ry., resigning as General Manager in 1904.

Mr. Elver L. Shinbur and Miss Anna M. Leland were married Oct. 10 in Ann Arbor, Mich. Mr. Shinbur is an engineer in the U. S. Reclamation Service in charge of construction of the second 50 miles of the Interstate Canal. His headquarters are at Mitchell, Neb.

Mr. John B. Mahoney and Miss Olive M. Stuart were married recently at Sandy Hill, N. Y. Mr. Mahoney is in the employ of the Hudson River Power Co., and at present is Superintendent of Construction on a large dam being built at Utica, N. Y. Mr. and Mrs. Mahoney reside in Utica.

Mr. F. E. Davidson, who for the past five years has been Structural Engineer for the Illinois Steel Co., has been appointed Architect for the Western Electric Co., with offices at Chicago. He will have charge of the design and construction work of all the extensive structural work carried out by the company.

Mr. Emory Clay Crum and Miss Ethel Marion Myers were married Oct. 26 at the home of the bride's parents, Mr. and Mrs. Thos. F. Myers, Frederick, Md. Mr. Crum was educated at Washington and Lee University. He has held various position is the engineering line, and is at present Resident Engineer of the New York, Auburn & Lansing R. R. Mr. and Mrs. Crum will reside in Auburn, N. Y.

The late George W. Catt, whose obituary notice appeared in our issue of Oct. 12, disposed, by bequest, of property to the amount of about $350,000. The property is bequeathed to his widow, but at her death one-half the property is to revert to the Iowa State College of Agriculture and the Mechanic Arts at Ames, Iowa, where it is to be used in the establishment of scholarships for the aid of needy students.

Mr. Arthur Maguire has been appointed Chief Engineer of the Las Vegas & Tonopah R. R., a new company recently incorporated to build a branch of the San Pedro, Los Angeles & Salt Lake R. R., from Las Vegas to Tonopah, Nev. Mr. John Conway, hitherto connected with the Engineering Department of the San Pedro, Los Angeles & Salt Lake R. R., has been appointed Superintendent for the new road.

Obituary.

Henry S. Storrs, General Superintendent of the Lake Shore & Michigan Southern Ry., died Oct. 25, at Cleveland, O., of paralysis, aged 57 years.

Jospeh M. Douglass, of the firm of Douglass Bros., contractors and builders, of Philadelphia, died Oct. 26, at his home in that city. He was 71 years old.

A. A. Gaddis, at one time General Manager of the Atlantic & Pacific Ry. (now the Santa Fe Pacific), died Oct. 30, in Brunswick, Ga. Mr. Gaddis was New York agent of the Erie R. R. in the sixties and subsequently organized the New Jersey Lighterage Co. and became its President. He had been successively General Manager of the Housatonic R. R., the Ogdensburg & Lake Champlain R. R., and Vice-President and General Manager of the Brunswick & Western R. R. of Georgia.

Mr. Frank Eugene Kidder, Ph.D., C. E., well known to engineers as the author of "Kidder's Architects and Engineers Pocket Book," died at his home in Denver, Colo., on Oct. 27, 1905. Mr. Kidder was born in Bangor, Me., Nov. 3, 1859, making him 46 years of age at the time of his death. He was a graduate of the Maine State College in 1878, and afterwards took special courses at Cornell University and the Massachusetts Institute of Technology. Mr. Kidder practiced in Boston, Mass., and in New York City for a number of years, but became best known as an authority on building construction after his residence in Denver, Colo, whither he moved about 16 years ago, and where he built up a large consulting practice. Besides the pocket book by which he was best known, Mr. Kidder wrote "Building Construction and Superintendence" and "Churches and Chapels." He was also a voluminous contributor to the architectural and engineering journals. Mr. Kidder was a Fellow of the American Institue of Architects.

ENGINEERING SOCIETIES.

COMING MEETINGS.

MAINTENANCE OF WAY MASTER PAINTERS' ASSOCIATION.
Nov. 13, 14. Annual meeting at Cincinnati, O. Secy., H. J. Schnell, 100 William St., New York, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 16, 17. Annual general meeting at New York, N. Y. Secy., Wm. J. Baxter, 12 West 31st St., New York, N. Y.

AMERICAN MINING CONGRESS.
Nov. 14 to 18. Congress at El Paso, Tex. Secy., J. F. Calbreath, Jr., Denver, Colo.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
Nov. 21. Annual convention at St. Louis, Mo. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 4 and 5. Annual meeting at New York, N. Y. Secy., W. H. Ross, 258 Broadway, New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual meeting at New York, N. Y. Secy., F. R. Hutton, 12 West 31st St., New York.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 9 to 12, 1906. Annual convention at Milwaukee, Wis. Secy., C. C. Brown, Commercial Club Bldg., Indianapolis, Ind.

MICHIGAN ENGINEERING SOCIETY.
Jan. 9, 10, 1906. Annual convention at Lansing, Mich. Secy., F. Hodgman, Climax, Mich.

BROOKLYN ENGINEERS' CLUB.—At the club's next meeting, Nov. 9, at 197 Montague St., Brooklyn, N. Y., a paper will be read by Mr. H. W. Woodcock on the subject "The Brooklyn Grade Crossing Commission and its Work."

CENTRAL RAILWAY CLUB.—At the next meeting, to be held 2 p. m. Nov. 10 at the Hotel Iroquois, Buffalo, N. Y., two papers will be presented: "Fuel Combustion," by Mr. G. F. Dillon, and "Railroad Accidents," by Mr. J. B. Morford. The Revised Rules of Interchange will also be discussed. Secy., H. D. Vought, 62 Liberty St., New York, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.—A regular meeting will be held at the headquarters, Tremont Temple, Boston, Mass., on Nov. 8, the technical session beginning at 2 p. m. A paper entitled "On the Present Relative Responsibility of Public Water Supplies and Other Factors in the Causation of Typhoid Fever" will be read by Profs. W. T. Sedgwick and C. E. A. Winslow. Dr. Magrath, of the State Board of Health, and Mr. E. E. Lochridge will discuss the subject. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The following nominations for officers have been sent out on the official ballot of the society: For President, Fred W. Taylor, Consulting Engineer, Philadelphia, Pa.; for Vice-Presidents, Walter M. McFarland, Acting V.-P. of Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.; Edward N. Trump, Genl. Mgr. Solway Process Co., Syracuse, N. Y.; Robert C. McKinney, Prest. Niles-Bement-Pond Co., New York, N. Y.; for Managers, Walter Laidlaw, V.-P. Laidlaw-Dunn-Gordon Co., Cincinnati, O.; Frank G. Tallman, Brown Hoisting & Conveying Machy. Co., Cleveland, O.; Fredk. M. Prescott, Prest. F. M. Prescott Steam Pump Co., Milwaukee, Wis.; for Treasurer, Wm. H. Wiley, New York, N. Y.

AMERICAN RAILWAY ASSOCIATION.—The Fall meeting of the American Railway Association was held at the Auditorium Hotel, Chicago, Ill., on Wednesday, Oct. 25, 1905. President Stuyvesant Fish was in the chair. There were about 120 members in attendance, represented by 175 delegates.

The Executive Committee reported that the membership now comprises 287 members, operating 222,158 miles, and that the associate membership comprises 19 members, operating 588 miles. The Committee recommended the appointment of a new committee by the American Railway Association, to consider the subject of Uniform Rail and Wheel Sections.

The Committee on Transportation of Explosives presented Regulations for the Transportation of Explosives, which were approved by the Association. A full abstract of this report will be given in the next issue of Engineering News.

The Committee on Train Rules reported that considerable progress had been made with the general revision of the Standard Code of Train Rules for Single and Double Track which it had undertaken. The Committee on Car Service presented a report embodying a recommendation covering some slight changes in the Car Service and the Per Diem rules; it also presented a standard form of contract to be entered into between all companies which may desire to use each others' tracks in case of an obstruction or washout. The Committee further recommended that the per diem rate for the use of freight cars be made 25 cts. instead of 20 cts. per day, with a penalty rate of 75 cts. after 30 days, and that on all roads whose aggregate mileage is 2,000 miles or more, the penalty rate shall commence after a car is held forty days instead of thirty. These several recommendations were approved and ordered submitted to a letter ballot. Reports were also presented by the Commitee on Safety Appliances, the Committee on Statistical Inquiry and the Committee on Standard Cipher Code.

Mr. Theo. Voorhees, first vice-president of the Philadelphia & Reading Ry., was re-elected first vice-president. The following companies were elected members of the Committee on Car Service: C. & W. I. R. R., Mo. Pac. Ry., N. Y. C. & St. L. R. R. The following companies were elected members of the Committee on Safety Appliances: C. & O. Ry., I. C. R. R., Pa. Lines West. [illegible] ing were elected members of the Committee [illegible] nations: W. A. Gardner, Gen. Mgr., C. & N. [illegible] H. Smith, Gen. Mgr., N. Y. C. & H. R. R. R.

The next meeting of the Association will [illegible] Chicago, Ill., on Wednesday, April 25, 1906. F. Allen, 24 Park Place, New York.

AMERICAN INSTITUTE OF ELECTRICAL [illegible]NEERS.—Three papers of exceptional interest [illegible] before the last meeting, held at the Edison [illegible] 24 West 27th St., New York, on the evening [illegible] They are: "Some Experiences with Lightning [illegible] Apparatus," by J. C. Smith; "Lightning Arr[illegible] Italian High-Tension Transmission Lines," by [illegible] Torchio; and "Performance of Lightning Arr[illegible] Transmission Lines," by N. J. Neall. The [illegible] stated briefly the experience had with lightning [illegible] on the 85-mile Shawinigan Falls-Montreal tra[illegible] line; horn arresters proved especially useful [illegible] carrying off larger discharges than other forms [illegible] arrester previously installed. The paper of Mr. [illegible] described the Gola "Series" lightning-arrester [illegible] water-resistance static discharger, both of which are used to some extent on Italian transmission lines. The third paper, by Mr. Neall, presented a summary of a series of experience-records on the action of lightning-arresters in actual service on various transmission lines. These records were kept by the lines in question at the instance of the Westinghouse Electric & Mfg. Co., who furnished specially-devised test papers for insertion in the arrester gaps. These papers were inspected and replaced at frequent intervals, never more than a week, and by the puncture holes indicated the presence and approximate character of the discharges which crossed the gap. The records as a whole showed that modern arrester installations work quite constantly and well. Specific conclusions must await further collecting of records kept in a way similar to that outlined.

A lively discussion followed, in which Messrs P. H. Thomas, C. F. Scott, W. S. Franklin, W. H. Patchell (London), H. C. Wirt, H. G. Stott, C. P. Steinmetz and others engaged. Only a few of the points advanced in the discussion can be noted here. Mr. Thomas suggested that the better results on the Shawinigan line after horn arresters were installed may be due in part to improvement in the insulation of the system which was made about the same time. Arresters at some distance from stations, 1 to 3 miles, might be useful in giving added station protection. Mr. Scott remarked that good experience as concerns lightning arresters has resulted on both the Shawinigan and the Missouri River lines, though the first has grounded neutral while the second is completely insulated. The latter has in fact had more lightning interference on some 2,000-volt distribution lines than on the 55,000-volt main lines. A serious problem of lightning protection at present seems to be the protection of poles; the protection of stations and apparatus seems to be fairly well solved. Prof. Franklin referred to the energy-dissipation which must occur in a lightning or static discharge path, and suggested a form of leakage path for this purpose: a length of terra cotta pipe painted with platinum chloride solution and then fired. He suggested also that poles might be protected to some extent by a slightly conducting paint. Mr. Patchell related that on a 10,000-volt cable transmission in London one type of horn arrester had proved useless, as the large machine current formed beads on their edges, and so destroyed the gap, each time the gap discharged. Another form of horn arrester, with a carbon facing, worked better. The influence of atmospheric moisture was always very great, changing the calibration of the gap as the relative humidity of the air changes. The gaps are fitted with relays in the earth connection to ring a bell whenever a discharge occurs. It is found that most discharges occur in the morning, when the load comes on. A curious thing noticed in the cable system is that after a fault has occurred, surges in the cable are noticeable for several hours. Mr. Steinmetz gave a general review of the subject of lightning protection, including protection against surges, or "internal lightning," and against external lightning. The latter is completely guarded against by a grounded sheathing, or by running the conductors underground. Grounded wires over or around the wires of a transmission line are of value, but they must be of suitable character and arrangement. Discharge gaps, with various series arrangements to reduce the possibility of holding an arc, series resistance to make the discharge non-oscillatory, and coils to protect the system from surges, are means of getting rid of external lightning rather than keeping it away. He emphasized the fact that not all is known about lightning. The globular form, as an instance, is wholly unexplained as yet, and we are not even familiar with the typical phenomena of its occurrence.

A special incident of the meeting was the exhibition of a silver memorial tablet presented by the Associazione Elettrotecnica Italiana in recognition of the courtesies extended to it on the occasion of its American tour in 1904. This tablet will be given a prominent place in the headquarters of the society in the Union Engineering Building now under construction.